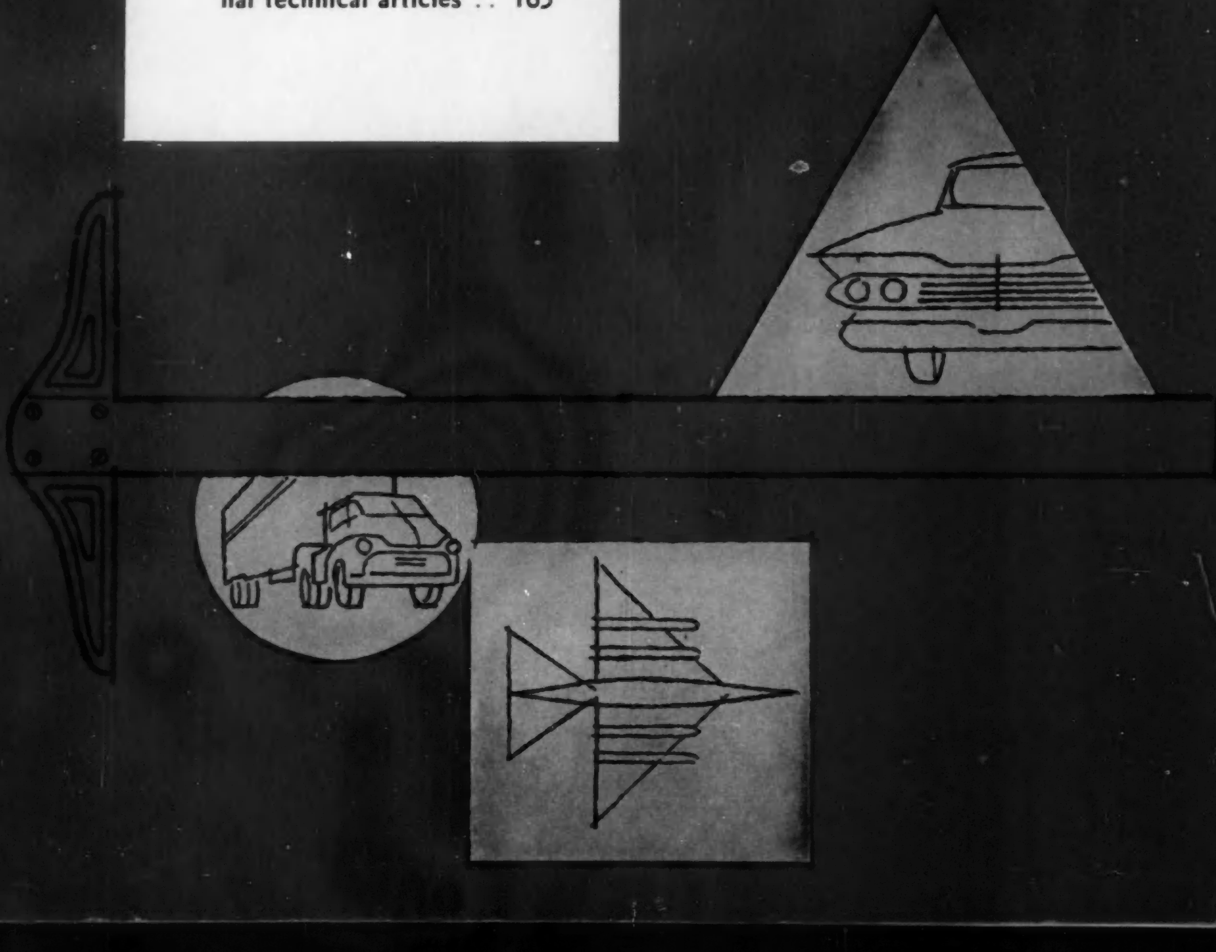
Published by THE SOCIETY OF AUTOMOTIVE ENGINEERS

DECEMBER 1961

SAE JOURNAL



SAE JOURNAL

Society of Automotive Engineers

PUBLICATION DIVISION

manager and editor, David L. Staiger

SAE JOURNAL

editor, Norman G. Shidle
associate editor, David L. Staiger
managing editor, Eleanor D. Allen
technical editor, Otto W. Vathke
technical editor, Saul J. Laskin
engineering editor, Walter G. Patton
production, Mary Grillon

OFFICERS OF SAE

president, A. A. Kucher
treasurer, G. A. Delaney
sec. & gen. mgr., Joseph Gilbert

SAE PUBLICATION COMMITTEE

chairman, Leonard Raymond
M. G. Beard
R. S. Frank
T. L. Swansen
W. Paul Eddy
A. O. Willey

Publication Office
10 McGovern Ave., Lancaster, Pa.

Society Headquarters
Editorial and Advertising Office
485 Lexington Ave., New York 17, N. Y.
Tel: OXford 7-3340; Teletype: NY1 228

Detroit Branch manager, G. J. Gaudaen
635 New Center Bldg., Detroit 2, Mich.
Tel: TRinity 1-1772; Teletype: DE 826

Western Branch manager, E. W. Rentz, Jr.
714 W. Olympic Blvd., Los Angeles 15, Calif.
Tel: RIchmond 9-6559

ADVERTISING OFFICES

advertising manager, Edward D. Boyer
Pennsylvania, New York, and East
485 Lexington Ave., New York 17, N. Y.

Fred Wilks
Eastern Michigan and Eastern Ohio
635 New Center Bldg., Detroit 2, Mich.

W. W. Milne
Midwest and Western Ohio
7530 Sheridan Rd., Chicago 26, Ill.

Pacific Coast Reps., Chris Dunkle & Assocs.
740 S. Western Ave., Los Angeles 5, Calif.

European Rep., Brayton Nichols
7 Blenheim St., London W.1, England

Contents • December, 1961

INDEX of 1961 SAE Journal technical articles appears in this issue

To order papers on which articles are based, see p. 6.

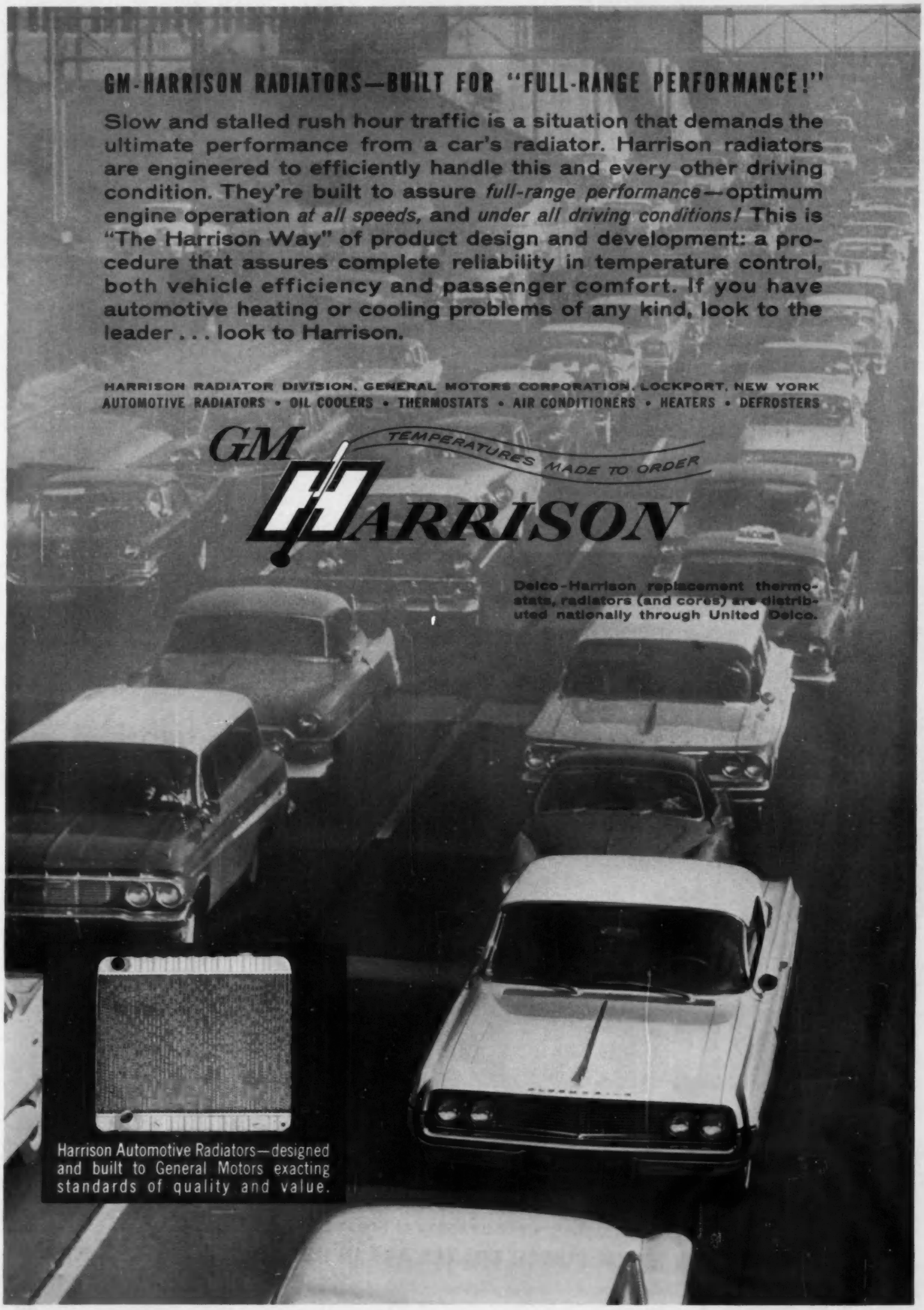
Continued on page 2

Contents • December, 1961 • Continued

More on page 1 To order papers on which articles are based, see p. 6.

A complete index of all Journal technical articles, from January through December, will appear in the December issue. All Journal technical articles are indexed by Engineering Index, Inc. SAE Journal is available on microfilm from University Microfilms, Ann Arbor, Mich.

SAE JOURNAL, December, 1961, Vol. 69, No. 12. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 485 Lexington Ave., New York 17, N. Y. $1 per number; $12 per year; foreign $14 per year; to members 50¢ per number, $5 per year. Entered as second class matter, Sept. 15, 1948, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of Feb. 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1918. Additional entry at New York, N. Y. Second class postage paid at Lancaster, Pa. and additional office N. Y. C.


GM-HARRISON RADIATORS—BUILT FOR "FULL-RANGE PERFORMANCE!"
Slow and stalled rush hour traffic is a situation that demands the ultimate performance from a car's radiator. Harrison radiators are engineered to efficiently handle this and every other driving condition. They're built to assure *full-range performance*—optimum engine operation *at all speeds*, and *under all driving conditions!* This is "The Harrison Way" of product design and development: a procedure that assures complete reliability in temperature control, both vehicle efficiency and passenger comfort. If you have automotive heating or cooling problems of any kind, look to the leader . . . look to Harrison.
HARRISON RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, NEW YORK
AUTOMOTIVE RADIATORS • OIL COOLERS • THERMOSTATS • AIR CONDITIONERS • HEATERS • DEFROSTERS
GM HARRISON
TEMPERATURES MADE TO ORDER
Delco-Harrison replacement thermostats, radiators (and cores) are distributed nationally through United Delco.
Harrison Automotive Radiators—designed and built to General Motors exacting standards of quality and value.

Briefs of SAE PAPERS

These digests are provided by ENGINEERING INDEX, which each year abstracts 30,000 engineering articles from 1500 different publications and classifies them into 249 "fields of engineering interest."

To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.

AEROSPACECRAFT

Analog Computer Simulation of Gas Turbine Engines for Control Study, V. L. LARROWE, M. M. SPENCER. Paper No. 398A. Various ways in which simulator may be used during process of designing engine controls: steady state engine performance data, transient response data, determination of surge region, maximum acceleration capability, rotor deceleration rate, and engine sensitivity to changes in input variables; testing control designs with engine simulator; details of simulator for simple unaugmented single spool turbojet engine.

Literal Acceleration Limiting Fuel Control for Gas Turbine Engines, A. N. CARRAS. Paper No. 398B. Mathematical derivation of several methods of sensing engine acceleration, study of hardware means of fulfilling mathematical models and results of computer analysis, made at AiResearch Mfg. Co. Div., Garrett Corp., where acceleration limiter was used in conjunction with conventional proportional integral control on solid and split shaft gas turbine.

FUELS & LUBRICANTS

Oil Additives — Friend of Equipment Designer, L. W. MANLEY, N. V. MESSINA. Paper No. 397A. Common types and functions of lubricating oil additives, relating to viscosity index improvers, detergent-dispersant additives, metal deactivators and oxidation inhibitors, extreme pressure gear lubricant additives, and friction modifying or "lubricity" additives, miscellaneous additives; application of additive technology in formulation of lubricants for new equipment; effect additives have on some of important performance requirements of transaxle fluid is summarized.

Additives in Lubricants, P. KALIL. Paper No. 397B. Pertinent information on commonly used lubricant additives is summarized listing reasons for use of specific types of additives: oxidation-corrosion inhibitors, detergent-dispersants, oiliness film strength, EP, and antiwear agents, rust preventives, metal deactivators, stringiness or tackiness agents, emulsifiers, dyes, color stabilizers, odor control and antiseptic agents, pour point depressants, viscosity index improvers, antifoam compounds, and balanced additive combinations.

GROUND VEHICLES

Discussion of Steering Problems on Modern Heavy Trucks, T. I. MONROE. Paper No. 368A. Study of effect of heavier front end loads on steering efforts with center point shows that hand wheel torques remain high despite improvements in ratio and efficiency of steering gears and that center point axle designs do not have great effect in reducing static steering efforts; with regard to dynamic steering efforts, torque increases proportionately with load, velocity and angle of turn; center point axle designs reduce wheel efforts for moving vehicles.

Capacitance Type Clearance Probes for Turbomachinery, A. WARNICK, R. E. CONDIT, J. R. SECORD. Paper No. 382A. Approach used at Ford Motor Corp. in developing capacitive transducer to monitor running clearance between blade tips and shroud during testing of experimental turbomachines; block diagram of principal elements; transmission line, matching transformer, calibration and check, and compensation of pickup temperature drift; transducers with uncooled or water cooled miniature pickup, and double cooled pickup; high temperature calibration and test setup.

Future of Higher Horsepower Engines, K. W. SELF. Paper No. 384A. Factors influencing present and future

continued on p. 6

TEAR ALONG PERFORATION

Readers' Information Service

Advertising Information Available

- **If you would like further engineering information on any of the products ADVERTISED in this December 1961 issue, CIRCLE THE APPROPRIATE PAGE NUMBERS in the list BELOW. Requests will be forwarded to the advertisers.**

- **Please fill in your NAME, COMPANY, AND ADDRESS on the BACK of this form.**

3	24	127	147
4	25	128	148
7	26	129	149 top right
8	27	130	151
9	28	131	152
10	30	132	153
11	113	133	155
12	114	134	157 right
13	116	135	159
14	117	136	160
15	118	137	161
16	119	139	163
17	120	140	164
18	121	141	Inside front cover
19	122	142	Inside back cover
20	123	143	Outside back cover
21	124	144	
22	125	145	
23	126	146	

- **COMPLETE PAPERS on which December, 1961 SAE Journal articles are based are available in multilith form. CIRCLE PAPER NUMBERS ON THE BACK OF THIS FORM of any papers you wish to buy.**

Briefs of SAE PAPERS

continued from page 5

truck design are national highway program, operation of double bottoms on turnpikes, and AASHO road tests; higher horsepower can be accomplished by greater displacement, higher engine speed, and supercharging; advantages of V design diesel engine which offers means of getting more horsepower in less lengths and with lighter weight compared to in-line engine in same horsepower range; closest contender for power plant of intercity highway truck is gas turbine.

At What Point Does High Horsepower Cease to be Practical in Transport Operations? C. C. SAAL, F. W. PETRING. Paper No. 384B. Problem of operating costs of trucks is one of determining if overall cost of transportation to public will be bettered by increase in horsepower resulting in better utilization of equipment in terms of ton-mph or time saved; past trends in horsepower and tabulation of truck tractors tested in hill-climbing study conducted in 1938 and 1939; practical horsepower requirements and economic considerations.

Case for Aluminum Engine, J. M. SMITH. Paper No. 385A. Paper demonstrates suitability of aluminum-base alloys for principal automotive engine components; it is shown that use of aluminum in major engine parts is justified not only on basis of its commendable engineering properties, but also by cost savings; details of design in aluminum engine components which lead to maximum weight reduction consistent with minimum cost are illustrated.

Off-Highway Truck Progress Meets Challenge, D. L. BRYAN, G. W. GAARDER. Paper No. 385C. Development of off-highway truck is considered with respect to carrying capacity and component design; principal factors affecting carrying capacity are tire capacity, weight distribution, empty vehicle weight, and power availability; basis developments in component design: use of torque converter, both single stage and 3-stage, and development of heavy duty planetary drive axles; fluid energy systems; examples of various trucks.

Effect of High Horsepower on Transmission and Axle Operation and Design, N. R. BROWNYER. Paper No. 386A. Choice of units in driveline of vehicles for highway and private road operation are determined to some degree by engine power; factors that influence choice of units and in this order would be important in selecting driving axle are: gross weight, type of terrain, road speed, tire sie, axle and transmission ratios, engine torque and speed, and lubricants.

Effect of High Horsepower on Brake Operation and Design, S. JOHNSON, Jr. Paper No. 386B. Trucks with higher engine horsepower can be expected to operate at higher speeds and/or greater loads; relationship between horsepower and brake performance is shown; gross vehicle weight, "K" factor, brake lining coefficient of friction, brake drums, brake application time, vehicle stopping distance, frequency of braking and brake rating influence brake performance and must be considered if horsepower is increased.

Jacobs Engine Brake — New Concept in Vehicle Retarders, C. L. CUMMINS, Jr., G. S. HAVILAND. Paper No. 387A. Jacobs Engine Brake, available for Cummins NH series engines, converts power producing diesel engine into power absorbing air compressor for retarding vehicles; development of retarder using power required to compress air charge on compression strike for retarding and leasing before it could force piston downward on power stroke; operation details; effect on engine, driver and vehicle; vehicle performance.

Gearing Vehicle to Road, E. F. BURTON, H. B. HINDIN, W. S. McDOWELL. Paper No. 387B. Tire tread and road surfaces vary in frictional characteristics according to speed, temperature, and texture; coefficient of friction on dry pavement may vary from 0.35 to 1, on wet or lubricated conditions from as low as 0.05 on smooth ice to 0.90 on stone; service requirement is major factor in establishing basic tread configuration; types of heavy service tires designed for specific classes of service are shown; phases of skid testing at Lancaster test site of United States Rubber Co.

continued on p. 118

TEAR ALONG PERFORATION

Readers' Information Service

SAE Papers Available — December 1961 issue

- If you would like complete copies (in multilith form) of papers on which December SAE Journal articles are based CIRCLE THE APPROPRIATE PAPER NUMBERS in the list below. PAPER NUMBERS are indicated at the END of each article. PRICES are listed below.

S311	386B	391C	397A	403A	433B
S312	387A	392A	397B	403B	435C
368A	387B	393A	398A	404B	436A
376A	388A	393B	398B	405B	SP-186
380E	388B	394A	398D	415A	SP-222
382A	389B	394B	398E	418B	TR-135
384A	389C	395A	399A	420B	TR-191
384B	389D	395B	400B	420D	
385A	390A	396A	401A	427C	
385C	391A	396B	401B	427D	
386A	391B	396C	402A	431B	

PRICES: Papers; 75¢ each to members; $1.00 each to nonmembers.
SP-186: 50¢ each to members; $1.00 each to nonmembers.
SP-222: $4.00 each to members and nonmembers.
TR-135: $1.50 each to members; $3.00 each to nonmembers.
TR-191: $1.00 each to members; $2.00 each to nonmembers.

ORDER BLANK

TO: Society of Automotive Engineers, 485 Lexington Ave., New York 17, N.Y.

PLEASE SEND ME:

... The SAE Papers and Special Publications whose numbers I have circled above.

.... Check or coupons enclosed

.... Bill Company .... Bill me

☐

PLEASE SEND ME:

... Information about the advertisers' products and services circled on the back of this form.

☐

NAME ....

COMPANY ....

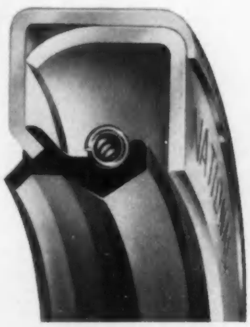
COMPANY ADDRESS ....

NATIONAL BUD* OIL SEALS

OVER 3,500 DIFFERENT SIZES IN PRODUCTION

BUD (Bonded Universal Design) Oil Seals field-proved in over 20 million cars, trucks and buses. Economical, ready when you need them.

National has complete tooling to provide you with a broad range of dependable BUD® seals covering virtually 100 shaft sizes for standard applications.

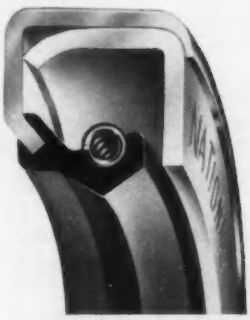


National 410,000

National 470,000

In National BUD seals, the lip is permanently bonded to the metal casing. This means less rubber needed, less frictional heat at contact points, longer life, less space required in applications. Bonded design eliminates internal leakage, and BUD seals are phosphate coated to avoid rust. With these features plus superior concentricity and rugged, simple design, BUD seals have proved outstanding in many millions of hours of widely varied field usage.

Available with single or dual lips; in single case design for standard precision shaft sealing, or double case design for heavy duty use of severe press fit. Sealing materials are available for temperatures from —80°F to +400° F, to operate in most oils or industrial fluids.



National 450,000

National 480,000

The bonded design was pioneered at National Seal—industry's oil seal headquarters for 40 years. If yours is a standard application, your National Seal field engineer has the proper BUD seal for prompt delivery; if yours is a special design his experience can help you cut sealing costs. He's listed in the Yellow Pages, under "Oil Seals."

Now National catalog lists BUD seals. Write for your copy today.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.

General Offices: Redwood City, California

Plants: Van Wert, Ohio; Downey and Redwood City, California

*BUD (Bonded Universal Design)

7320

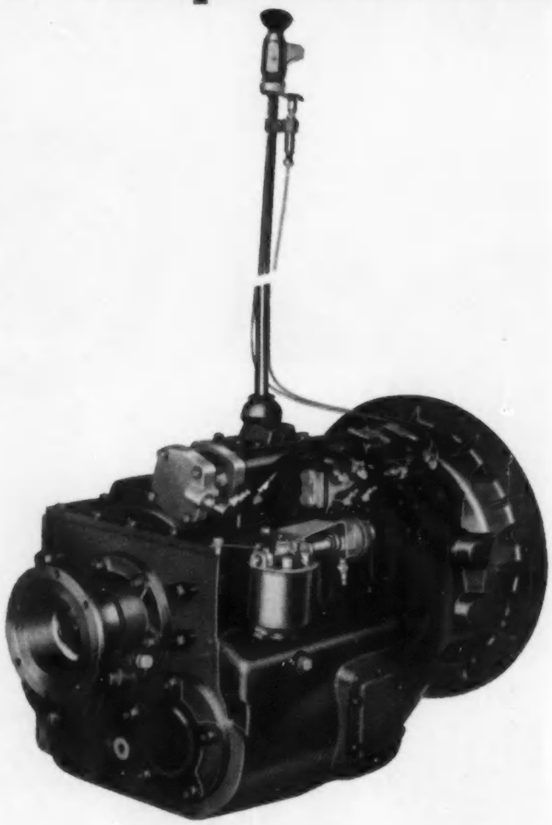
Now—A Spicer 12-Speed Trans-
(SYNCHRONIZED OR UNSYNCHRONIZED)
mission to Fit Your Requirements

As another step in Dana's continued program designed to keep pace with the varying requirements of the trucking industry, the availability of the 8125-U offers manufacturers of heavy-duty highway vehicles an option of synchronized or unsynchronized units in a multi-speed transmission. No other comparable transmission in the heavy-duty field offers this choice.

Because it provides sufficient low gear reduction (10.45 to 1), plus progressive, non-overlapping, close steps to handle varying road and load conditions, the use of supplemental gearing with the 8125-U is not required. The 12 evenly-spaced forward ratios promote efficient engine performance at all speeds. For example, the average R.P.M. spread between all gears, 1 through 12, is 455 R.P.M.

With the exception of the hand shift synchronizers, which are eliminated, Model 8125-U retains all the design and operating features of the Spicer fully-synchronized 12-speed box, Model 8125. Splitter and range shift synchronizers which are air operated have been retained.

An added feature to the Model 8125-U is the provision for a clutch brake. This brake facilitates shifting into first and reverse without severe gear clash by slowing down or stopping rotation of the transmission main drive gear and internal gears.



GENERAL SPECIFICATIONS:

	8125 ALUMINUM	8125-U ALUMINUM
WEIGHT (LESS CLUTCH)	600 LBS.	600 LBS.
CLUTCH HOUSING—S.A.E. No.	1—2	1—2
OIL CAPACITY (S.A.E. 50)	28 PTS.	28 PTS.
P.T.O. STANDARD OPENINGS	R/L 6-BOLT	R/L 6-BOLT
SHIFT CONTROL	O.H./REM	O.H./REM
OVERALL LENGTH	31.00"	31.375"
SPICER CLUTCH 15.5" 2-PLT.	140 LBS.	140 LBS.
14" 2-PLT.	96 LBS.	96 LBS.

AVAILABLE RATIOS Model 8125 & 8125-U

FORWARD		REVERSE
1st —10.45 to 1	7th—2.55 to 1	1st —10.45 to 1
2nd— 8.38 to 1	8th—2.05 to 1	2nd— 8.38 to 1
3rd— 6.52 to 1	9th—1.59 to 1	3rd— 6.52 to 1
4th — 5.23 to 1	10th—1.28 to 1	4th — 5.23 to 1
5th — 4.09 to 1	11th—1.00 to 1	5th — 4.09 to 1
6th — 3.28 to 1	12th— .80 to 1	6th — 3.28 to 1

As with the synchronized version, the 600-pound Model 8125-U, with standard all-aluminum case, is lighter and approximately 12 inches shorter than any multiple-speed transmission of comparable capacity on the market.

SPECIFY SPICER!

DANA Spicer **DANA CORPORATION**
Toledo 1, Ohio

SERVING TRANSPORTATION—Transmissions • Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Retarders • Power Take-Offs • Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes • Forgings • Stampings • Frames • Railway Drives

Spicer products available in Canada through Hayes Steel Products, Ltd., Merritton, Ontario

BFG MAGNESIUM WHEELS SAVE 1000 POUNDS FOR THIS AIRBORNE BULLDOZER

Big and husky though it is, this scraper-dozer for the U.S. Army Corps of Engineers has to be air transportable. The machine, designed by Barnes & Reinecke, Chicago, is a prototype for a whole series of construction, maintenance, and transportation equipment which can be moved by air.

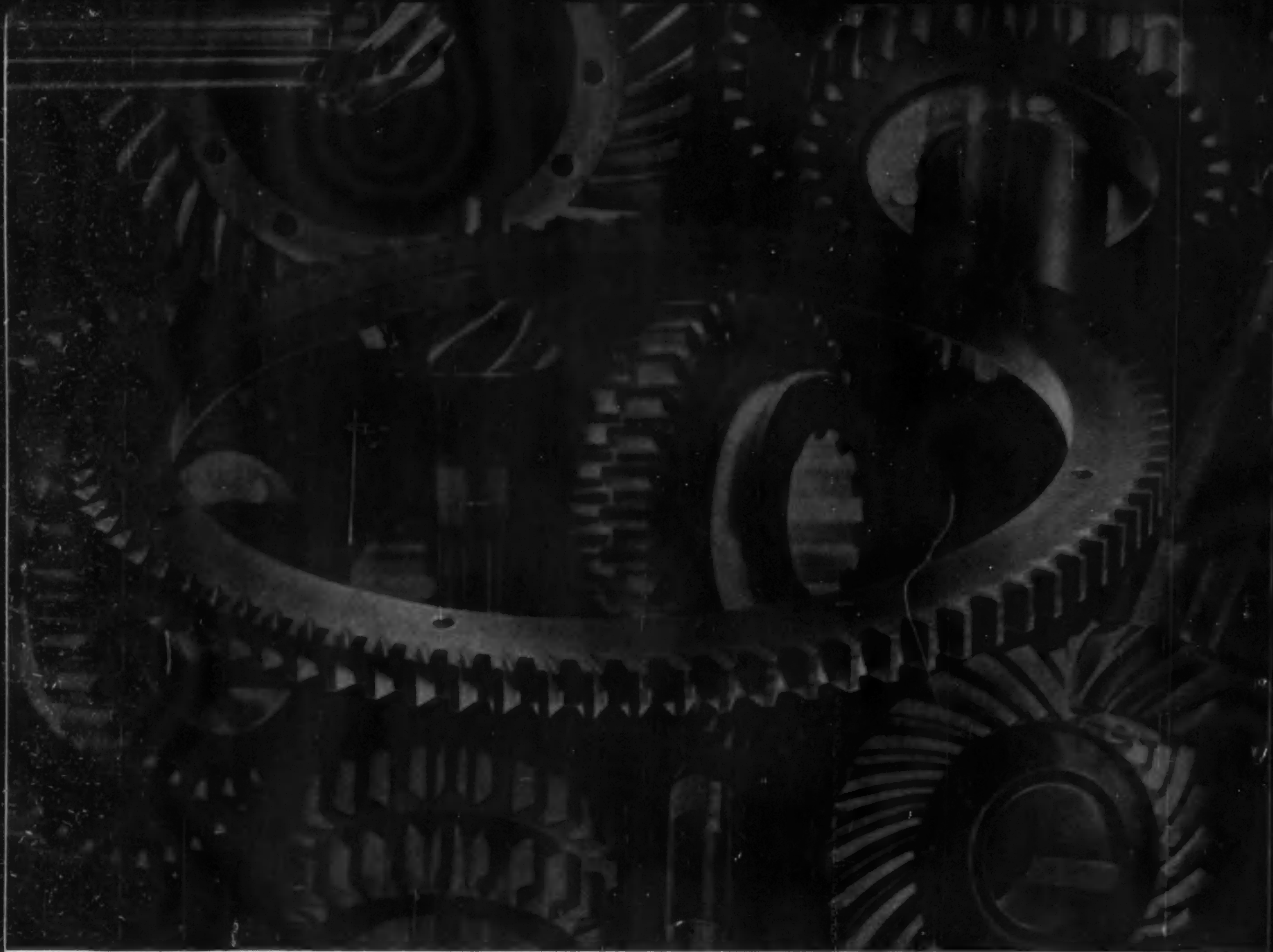
The designers turned to B.F.Goodrich for the wheel and brake system. Drawing on its long experience in producing aircraft wheels in light metals, BFG designed and built the wheels from cast magnesium, the brake drums from aluminum. Result—savings of 1000 pounds in total vehicle weight.

SUPERIOR STOPPING POWER, TOO

The scraper dozer is equipped with BFG Hi-Torque brakes, 20¼" x 3", to provide the ultimate in dependable braking power. Hi-Torques improve safety and controllability—stop vehicles in approximately half the distance required with conventional, two-shoe brakes. When you need light alloy wheels, or superior brakes for your off-road vehicles, check BFG. For complete technical data call or write *B.F.Goodrich Aerospace and Defense Products, a division of The B.F.Goodrich Company, Dept. SJ-12, Troy, Ohio.*

Hi-Torque brakes maintain full circle contact with brake drum for maximum braking surface.

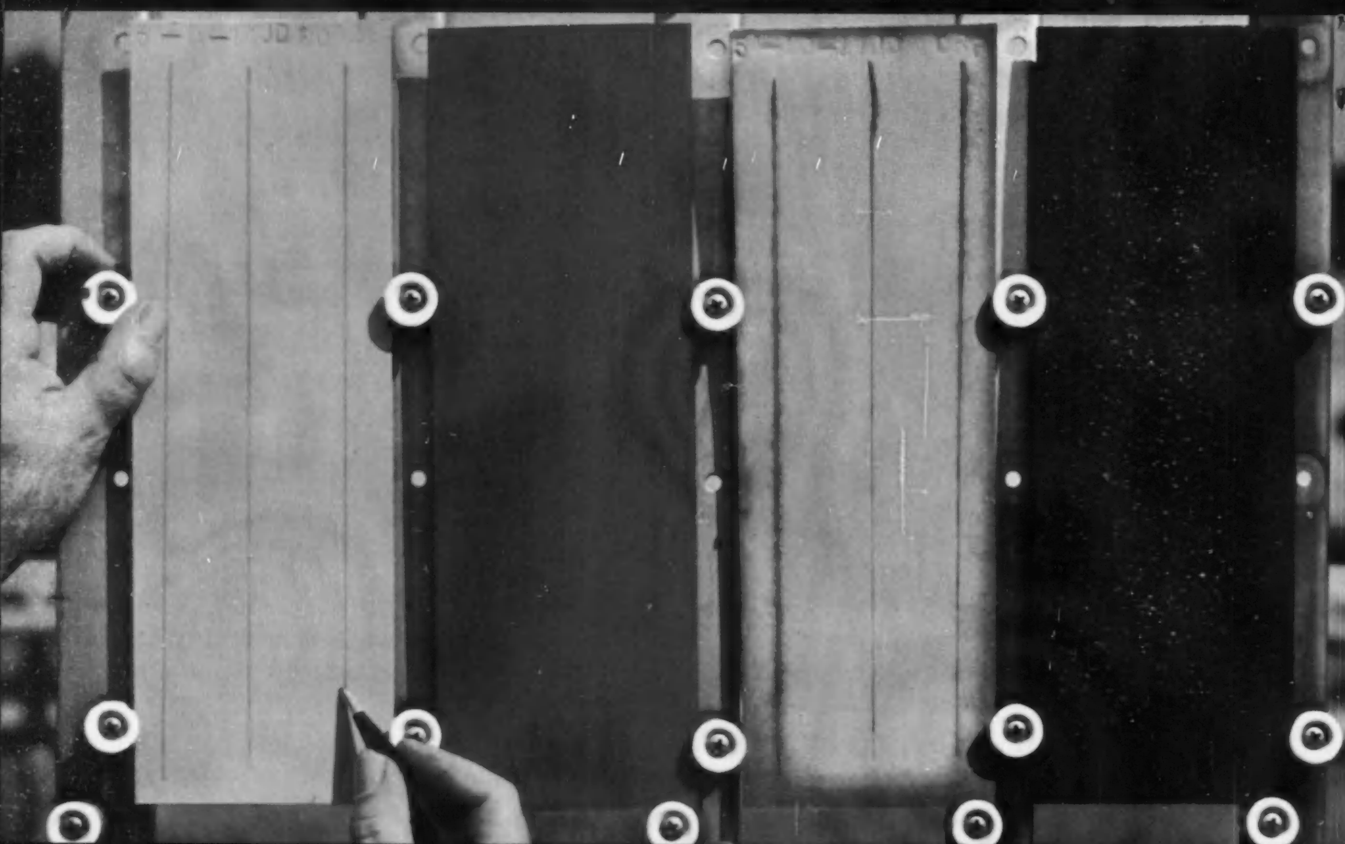
B.F.Goodrich **HI-TORQUE BRAKES**

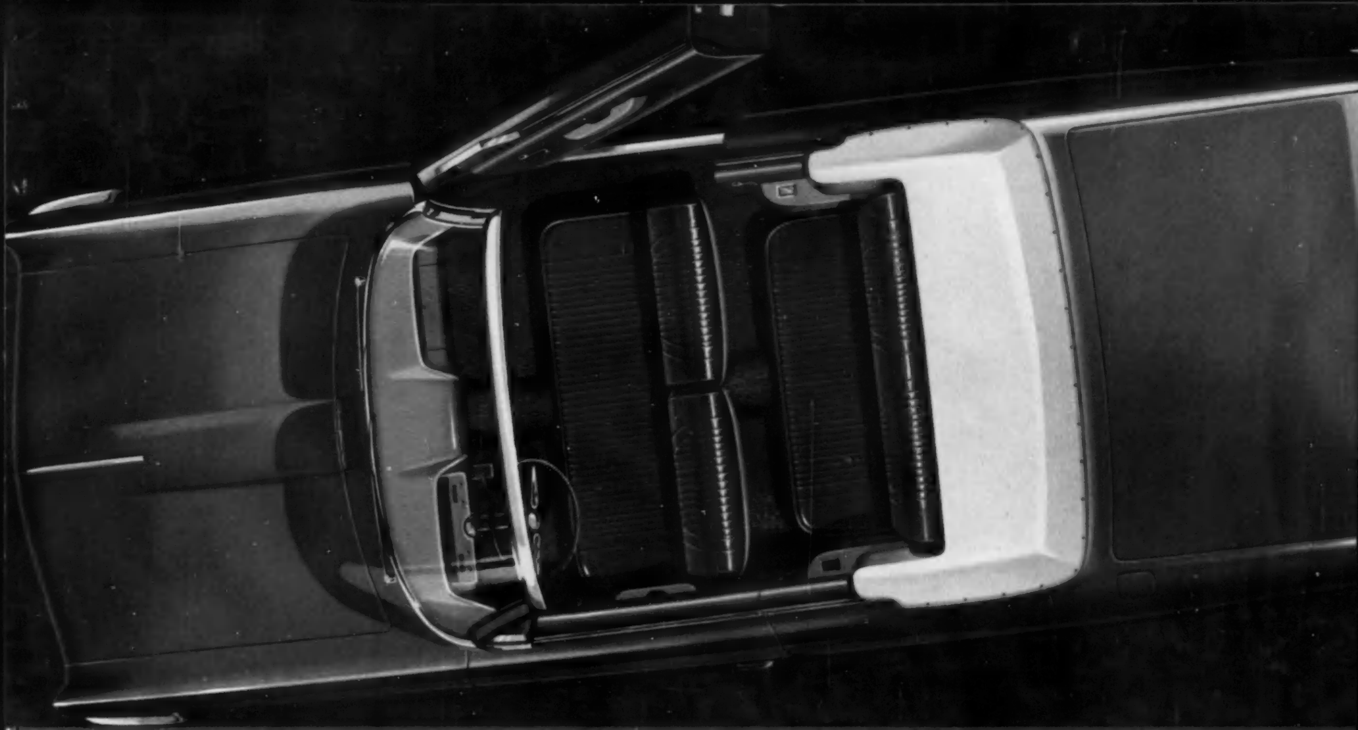


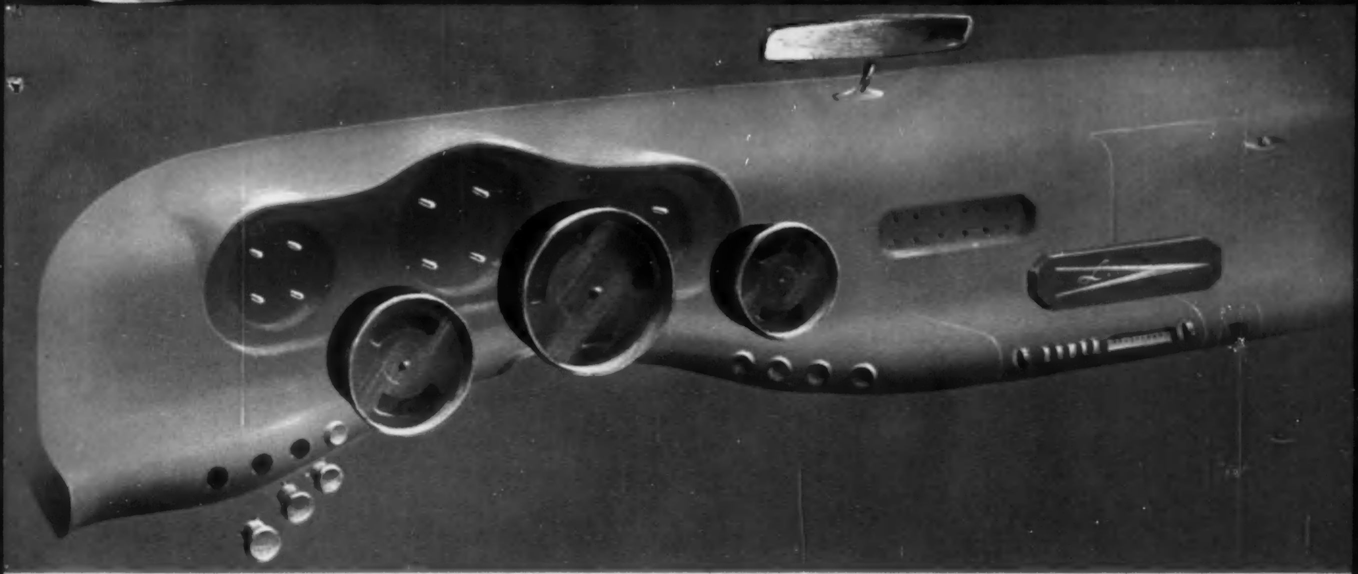
New steels are born at Armco

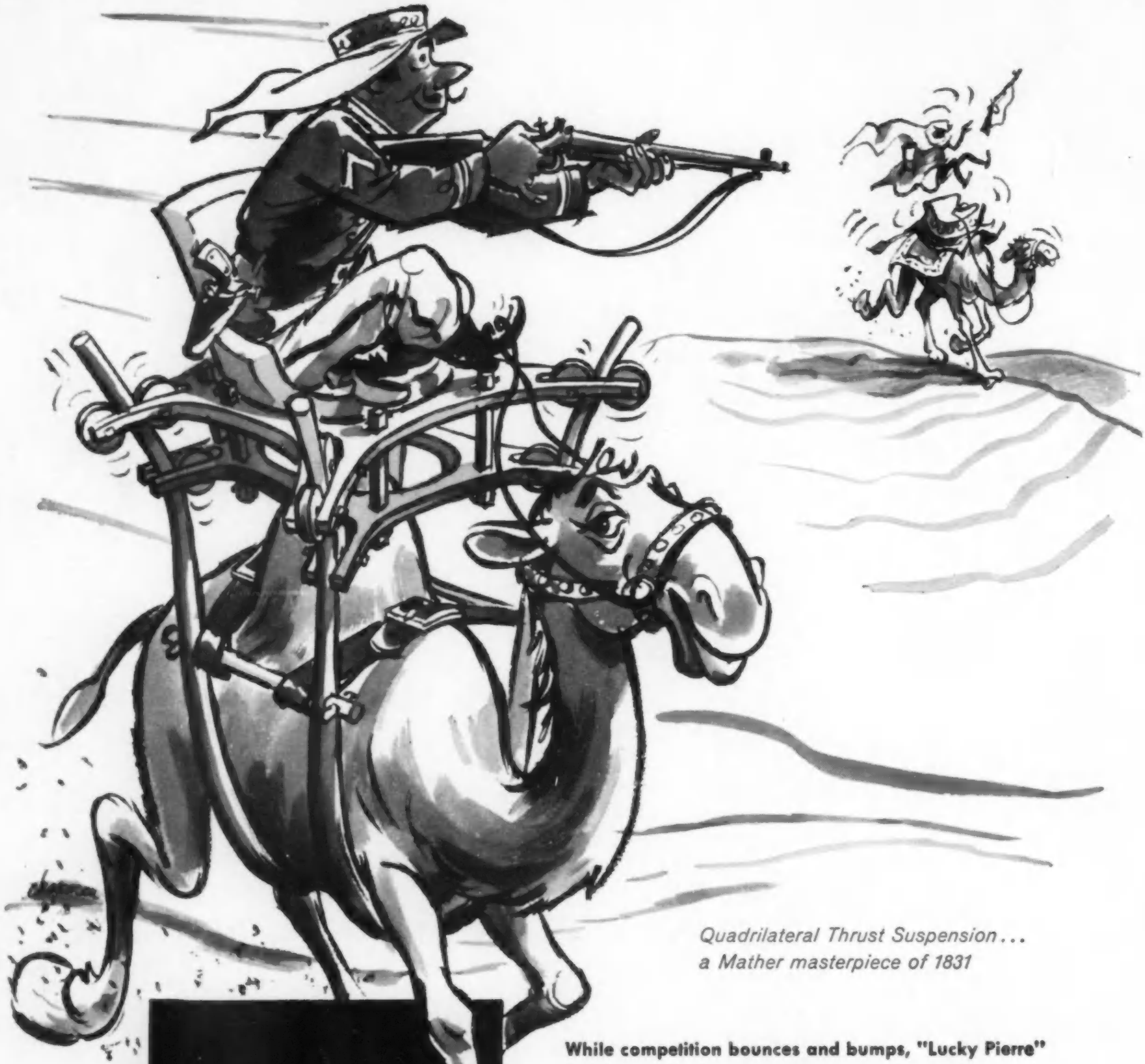
Rout rust, get fine finish, protect paint with NEW

Armco ZINCGRIP A,



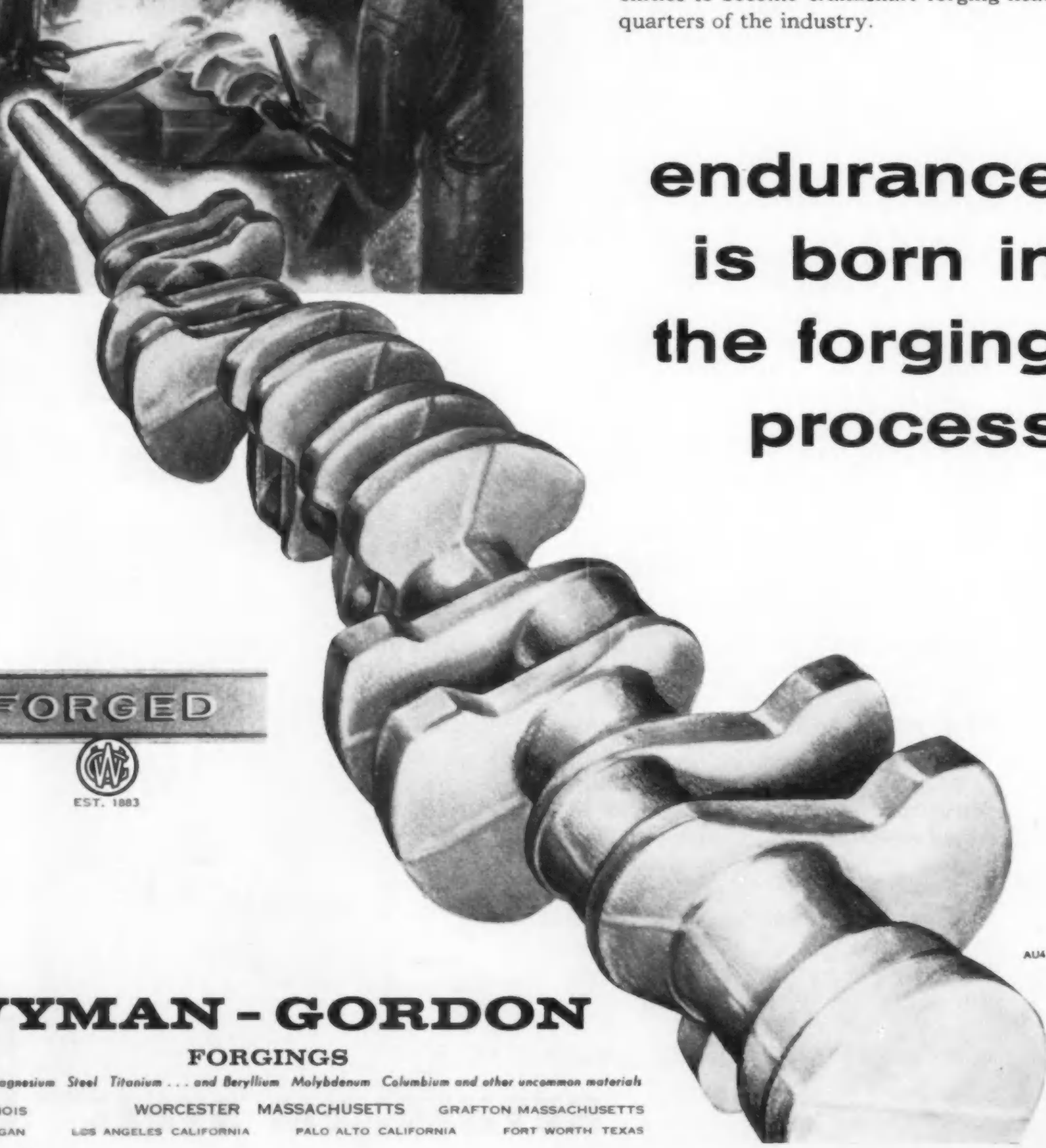






It's highly significant that in the long history of piston engines every design for rigorous service has relied on a forged crankshaft. One reason is the optimum improvement in metal quality achieved by forging's tremendous pressures in producing plastic flow of hot metal into skillfully designed dies. Not only is structure refined to the utmost, but grain flow—so essential to ultimate strength—is positioned for maximum resistance to design stress. From the very beginning Wyman-Gordon has served automotive customers with exceptional competence, experience and specialized facilities to become crankshaft forging headquarters of the industry.

endurance is born in the forging process



FORGED

EST. 1883

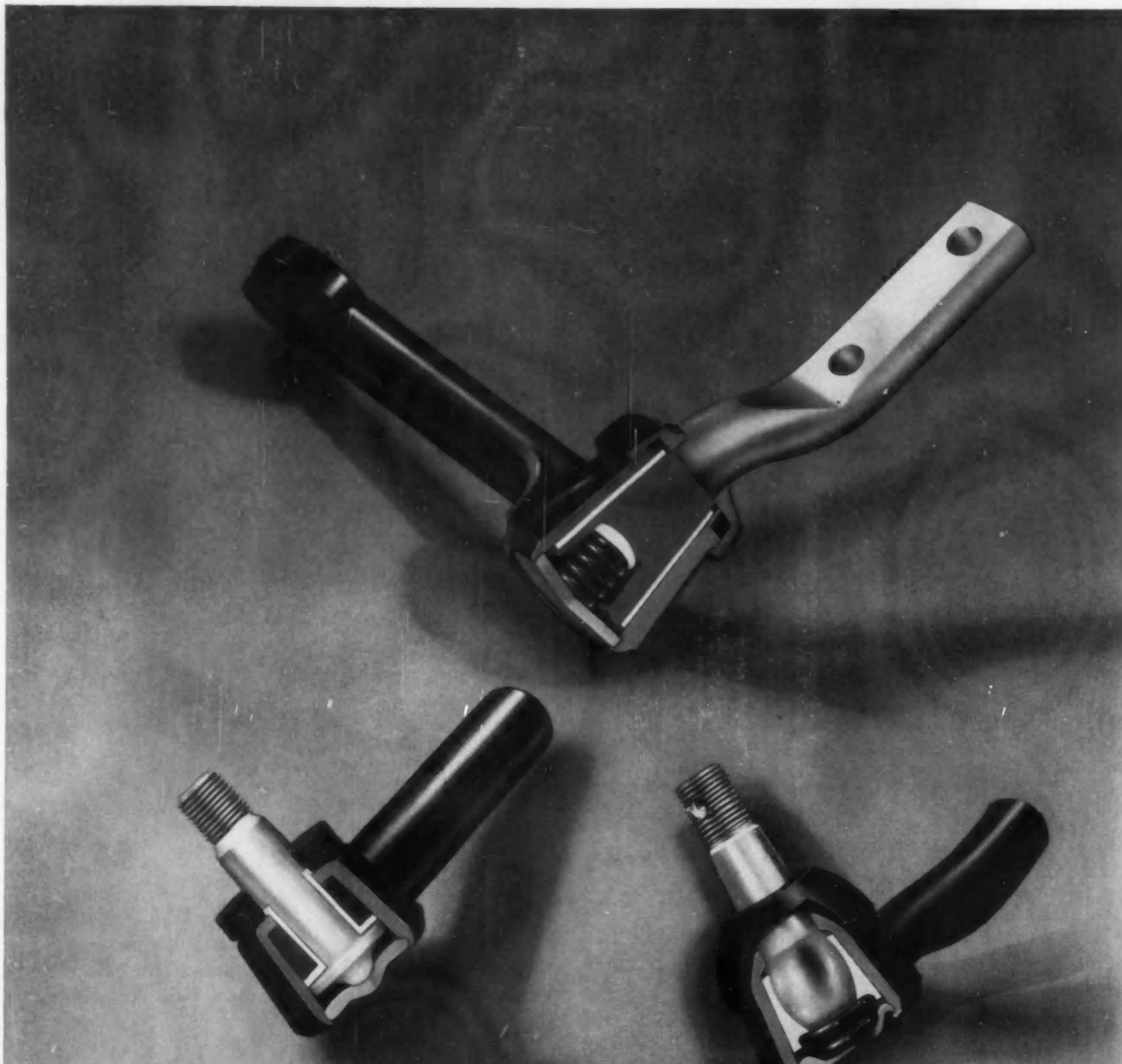
AU4

WYMAN - GORDON

FORGINGS

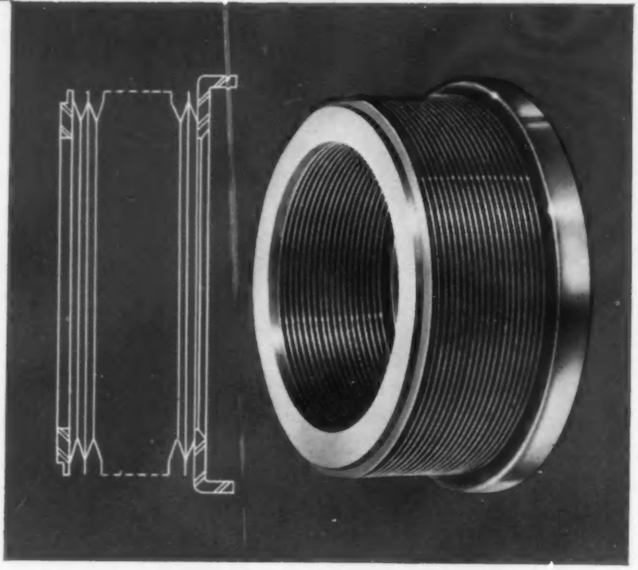
of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS · WORCESTER MASSACHUSETTS · GRAFTON MASSACHUSETTS
DETROIT MICHIGAN · LOS ANGELES CALIFORNIA · PALO ALTO CALIFORNIA · FORT WORTH TEXAS



C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1243 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

For Sake of Argument

We're All Consultants Sometimes . . .

There's a consulting aspect to almost every job, though it rarely shows on a job analysis form. How we react to opportunities to be a consultant can chart the course of our business lives.

Subordinates, associates, and supervisors all ask for our advice regularly or occasionally. But we don't always recognize a question, a comment, or a conversation as a request for advice. Sometimes we just wonder why subordinates can't learn to make their own decisions; why associates can't do their own jobs without bothering us; or how supervisors ever got to be supervisors if they can't answer the questions they keep asking us.

But usually we remember that a good consultant is made up of "one part knowledge, one part awareness, and two parts wisdom."* Then we recognize that people wouldn't bother coming to us for advice or comment unless they thought of us as a good consultant. They wouldn't ask us to participate in their thinking or their problems unless experience showed some helpful contributions.

"Consulting" gives a practical chance to scout the periphery of our job; to be helpful to everybody we work with; to see the constant relationship of our own job to overall company or department objectives. It also tends to slow down the volume of our individual production, interrupt our concentration on today's tasks, and force our minds to jump around from one subject to another. That's why our reaction to "consulting" gambits tends to chart our business course. . . . Each individual decides for himself whether the advantages of embracing consulting opportunities are greater than the disadvantages — in his particular case.

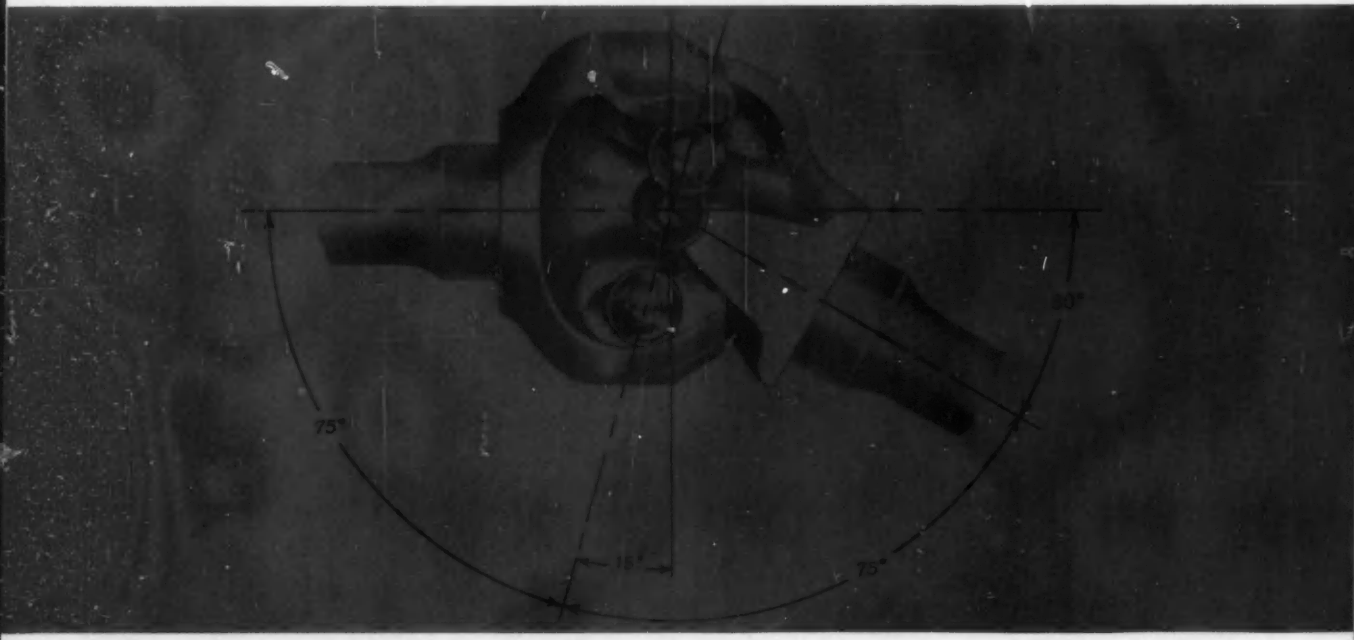
* See "What A Consultant Needs" on page 27, November SAE Journal.

Norman G. Shidle

CHOOSE BENDIX C-V UNIVERSAL JOINTS FOR LARGE-ANGLE, HIGH-TORQUE APPLICATIONS

The Bendix® Constant Velocity Universal Joint transmits angular movement at uniform velocity . . . at all shaft speeds, angles, torque loads. Types available to allow end motion; leave shafts unburdened by slip joints. Compact, spherical shape reduces space requirement. Send for free, detailed brochure: Bendix Automotive Products Division, South Bend, Indiana.

See the Bendix exhibit at the SAE Show, Detroit, January 8-12



Bendix Products Automotive Division

THE Bendix CORPORATION

chips

from SAE meetings, members, and committees

FUTURE Coordinating Research Council efforts toward development of test techniques in a standard engine will probably be centered around the basic CLR Oil Test Engine design. . . . At least, that's the recommendation of a CRC review group which has set up some conclusions about oil test engine techniques as a guide to setting up future test programs that relate to the single-cylinder CLR Oil Test Engine. . . . In the meantime, work is continuing on use of this engine in evaluating varnish and sludge-formation characteristics of fuels and lubricating oils in gasoline engines, when operated in light-duty, stop-and-start service.

CHEVROLET'S WIDE CUSTOMER CHOICE of body styles, colors, trims, and eqiupment options — but excluding accessories — provide enough combinations to build its entire year's output of passenger cars (1,850,000 in 1960) without making any two units exactly alike.

60,000 MILES is the average distance driven between each accident. Each accident fatality is separated by about 18 million miles of driving.

BRAKING FREQUENCY VARIES — even with the same type of vehicle operating between the same two cities. That's what figures published by the Indiana Turnpike Commission covering comparative runs between Chicago and New York show.

Over the turnpikes the average road speed was 40.93 mph, total brake applications — 194, total number of full stops — 58. Over the state highways average speed was 32.73 mph, total brake applications — 893, and total number of full stops — 243.

STANDARDS REFINED FOR SPACE AGE

Time: The new definition of a second of time is 1/31,556,925.9747 of the tropical year 1900.

Length: The meter is a length equal to 1,650,763.73 wavelengths in vacuum of the radiation corresponding to the transition between the energy levels of $2p_{10}$ and $5d_5$ of the atom krypton 86.

Yard: The international yard equals 0.9144 meter.

Inch: The international inch equals 25.4 millimeters.

Weight: The international pound is equal to 0.453 592 37 kilogram. This is exactly divisible by 7 to give the following value for the grain:

7000 grains equals 1 avoirdupois pound.

5760 grains equals 1 apothecary pound.

5760 grains equals 1 troy pound.

1 Imperial gallon equals 1.20094 United States gallon.

RESIDUAL STRESSES produced in high strength steel by machining or grinding may have a high tensile value at the immediate surface which can change to a high compressive stress at a depth of 0.001 to 0.002 in. below the surface.

THE SUN subtends an angle of approximately 32 minutes between its upper and lower limbs at the earth's distance.

Automobile Assembly Line Lingo

deadener — Silencing material sprayed on body panels.

dead spot — Area in a switch mechanism travel which is inoperative.

deck — 1. The operation of placing the body onto the chasis of the engine. 2. The closure for the trunk.

Disneyland — Engineering section of assembly plant.

dog leg — The shape or area at the front of the front door and rear of the rear door opening.

dolly — Small truck to transport parts or bodies.

AIRCRAFT HYDRAULIC SYSTEMS ARE GETTING MORE COMPLEX — The DC-3 had an approximate maximum hydraulic horsepower of 7; the DC-7 30 hp; the 707 — DC-8 — 880 types about 135 hp. The B-70 or supersonic transport is expected to run about 2000 hydraulic horsepower. By way of comparison, an automobile power steering system uses about 1.5 hp.

ALLIS-CHALMERS' FUEL-CELL-POWERED TRACTOR is so silent that, when it was driven around the plant, the engineers played a radio on it, to let people know they were coming — besides, the World Series was on, and they wanted to know how the games were going.

RESEARCHERS currently are working to establish tests for piston ring and piston fouling that will meet the requirements of a proposed new Ordnance specification for diesel-engine oils. The requirements for

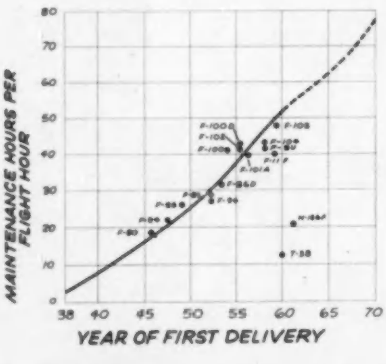
chips

from SAE meetings, members, and committees

the new spec are about halfway between those for MIL-L-2104A and MIL-L-145199. Generally speaking, MIL-L-2104A is for unsupercharged diesels; and MIL-L-145199 is for high-performance supercharged diesels.

It is understood that the proposed new Ordnance spec would be called MIL-L-2104B — to fit in between the other two . . . and it would be designed for use in high-performance unsupercharged or in low-performance supercharged diesels.

The proposed new spec is expected to include, not only the piston ring and piston fouling requirements for which researchers are seeking tests, but also for viscosity, pour point, flash point, and an number of other characteristics.



MANHOURS OF MAINTENANCE per flying hour has increased almost threefold for fighter aircraft in the past fifteen years. A similar growth curve can be shown for bomber aircraft. The new generation of fighters require as much maintenance as the B-47 bomber and as much as three times that for the B-17.

GUIDANCE AFTER TOUCHDOWN of an aircraft may be a future requirement. With automatic landing systems now under development, automatic control ceases shortly after touchdown and manual control is resumed; but an improved system would extend guidance until the aircraft is brought to rest. The pilot would still be responsible for brake and/or reverse thrust application, although this function could also become automatic.

DIESEL ENGINE INLET AIR, on many submarines, is taken from the battery rooms in order to eliminate a requirement for special ventilating fans and ducts. Despite the introduction of hydrogen, acid vapors, and other noxious products with this system, the diesels have not been troubled as much as one might think.

A HYPERSONIC Mach 7 transport might have to start its landing descent as far out as 800 nautical miles from its destination.

OLDER SUBMARINES are brought to the surface by displacing the sea water in the ballast tanks with air from a low pressure air compressor. On newer ships, the water is displaced with diesel exhaust. This eliminates the need for a sizeable motor and compressor, saving space and weight.

A B-58 AIRFRAME, less engines, gear, and systems, costs $60 to $65 per pound at current production rate.

SOME 50 MILLION DIESEL HORSEPOWER had been built for the Navy by the end of World War II for use in every type of craft, from 20 ft launches to aircraft carriers.

Since the end of the war approximately 8400 diesel engine installations have been made in new Navy ships and boats. At the present time, the Navy has some 6 million diesel horsepower installed.

ABOUT 40% of all fatal aircraft accidents occur during the approach and landing phases of flight.

EFFECTS OF TRANQUILIZERS on driving have been studied on an AAA driver training device.

NONMAGNETIC DIESELS, numbering in the thousands, have been used in a variety of minesweeping craft. They are used because of the low magnetic signature required for safe operation in mine infested waters. Some of these engines contain as much as 80%, by weight, of low permeability materials. Many are equipped with compressed air or nonmagnetic hydraulic starting systems.

AN AVERAGE AIRLINE PASSENGER walks about 650 ft from his parked car to the ticketing counter, and then about 950 ft from there to his airplane. This adds up to more than 5 times the length of a football field.

COMPLEXITY AND FAILURE RATE are definitely related according to a recent reliability study of jet engine components. As the number of pieces in a part goes up, down comes the mean time between failures. The same trend holds true regardless of the degree of development, but more design effort does generally improve life expectancy at any particular degree of complexity.

Material drawn from an
SAE Northwest Section paper

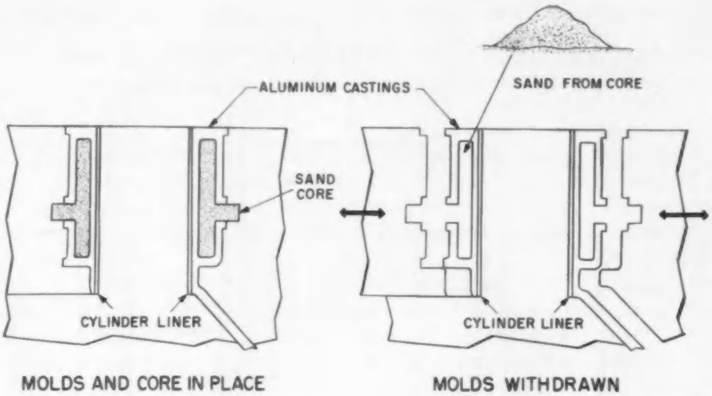


Fig. 1 — General Motors' aluminum engines are cast by the semi-permanent mold process illustrated here.

U.S. aluminum engines compared

Based on paper by

Jack D. Bryan
Perfect Circle Co.

HOW do U.S. aluminum passenger car engines differ from one another?

They are cast differently, for one thing. General Motors uses the semi-permanent mold process . . . where molten metal flows by gravity into steel external molds with sand cores forming the internal passages (Fig. 1). American Motors and Chrysler selected the high-pressure die casting method. In this process, illustrated by Fig. 2, a 2,000-ton machine forces metal into steel molds under 8,000–10,000 psi pressure. And the cylinder sleeves placed in the mold before casting are different than with the semi-permanent mold process.

The finish on the outside of the sleeves used in the die casting method is a spiny surface, called Spinylok — as shown at the right of Fig. 3. Thousands of points and crevices make the sleeve look like coarse sandpaper. As molten metal penetrates this spiny surface under high pressure, the liners are mechanically anchored to the aluminum. The semi-machined inside surfaces of the sleeves are finished after the block is cast. Their radial thickness after finishing is about 3/32 in.

Cylinder sleeves used with the semi-permanent mold process on the other hand, have a thread finish of 8 grooves-per-inch, 0.010 in. deep, making a corrugated surface. These grooves are machined on the outside diameter of the sleeves. . . . This surface — called Maxlok — has no sharp corners or cavities that would prevent molten metal at low pressure from flowing freely around the liner. It also provides a permanent mechanical bond between the two materials.

Both types of sleeve are of centrifugally cast iron — and have provided significant reductions in cylinder-bore wear. They are 20% harder than sleeves as cast in block gray-iron cylinders. And, in combination with aluminum, operate with cooler cylinder-wall temperatures. Because of these centrifugally-cast iron sleeves, these aluminum engines have been able to take advantage of aluminum's faster heat-transfer to achieve higher compression ratios and more hp-per-lb. (The Buick and Oldsmobile designs are very close to the 2-lb per hp that used to be standard in aircraft design, where aluminum was first used to best advantage.)

Other differences

Rambler's design of "free-standing" bores, a cylinder block without a continuous top deck (Fig. 4), is a noticeable departure from this company's previous production engines. Cylinder barrels are mutually supported by a siamese arrangement and tied to jacket walls near the bottoms. The water circulation area is open to inspection for dirt when the engine is disassembled.

Chrysler Corp.'s 64-lb die cast aluminum engine block has a similar arrangement, except that the barrels are not connected in pairs (Fig. 5). The combined thickness of iron and aluminum making up the cylinder-bore wall is 0.210 in. The crankshaft is supported by replaceable upper and lower cast iron main bearing caps, as shown in Fig. 6. They are line-bored as engine sets, and are replaced as a set if replacement of any cap is necessary. The

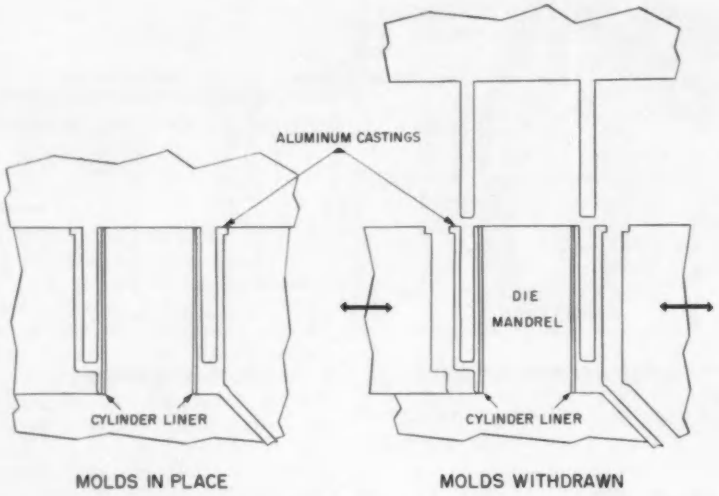


Fig. 2 — American Motors and Chrysler Corp. aluminum engines are made by the high-pressure die casting method illustrated here.

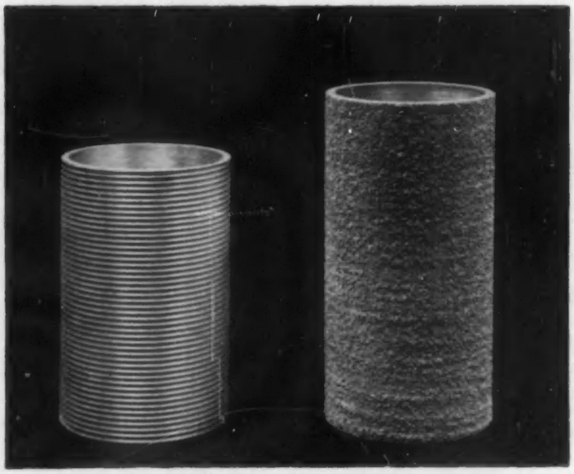


Fig. 3 — The outside of cylinder sleeves for designs produced by die-casting carries a spiny surface finish, as shown at RIGHT above. . . . Sleeves for designs produced by semi-permanent mold casting have a thread finish, as shown at LEFT above.

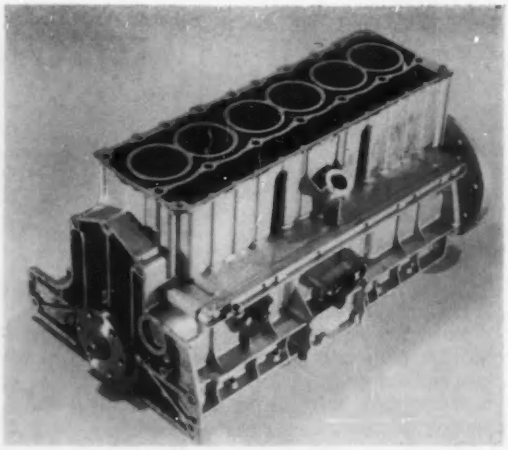


Fig. 4 — RAMBLER'S aluminum engine design has "free-standing" bores and a cylinder block without a continuous top deck.

U.S. aluminum engines compared ... continued

2-piece design suppresses engine noise and simplifies engine rebuilding in the crankshaft area.

No camshaft bushings are used in this Chrysler Corp. engine. The aluminum block material has good bearing qualities and provides adequate support to the camshaft. Should excess clearance exist after long service, it can be reduced to specifications by line-boring the block and inserting bushings available for the iron engine.

General Motors aluminum engines, though not radical in design, involve the most changes from previous iron-engine practice. Starting to design a new car and a new engine, GM could avoid many limitations in taking advantage of aluminum. They did so . . . by converting to aluminum for all major components (Fig. 7). Blocks, heads, intake manifolds, clutch housing, water pump, and timing gear covers are all cast from aluminum in the GM design. But GM uses iron for main bearing caps, cylinder bores, and other heavy-wear areas — as do both American Motors and Chrysler.

GM uses the same basic block for its three engines. The Buick and Pontiac blocks are identical. Oldsmobile has additional cylinder-head bolts and water passages. Each division has gone its own way on assemblies and parts. Using the same block is an

HERE IS A TIMELY COMPARISON — by a leading parts engineer — of the various aluminum engine designs now used in U. S. passenger cars.

The comparison is timely because more than a year of service experience is now available on all the designs. No new aluminum engines have been announced in the 1962-model year . . . but each of the engines introduced a year ago is being continued in production.

In addition to the first-in-production Corvair 6-cyl "pancake" engine, full scale water-cooled aluminum engines are standard on the Buick V-8 Special, the Oldsmobile V-8 F-85, and the Rambler Classic Six. Such engines are optional as V-8's on the Pontiac Tempest. An aluminum version of Chrysler's Slant Six is used in the Plymouth, Dodge Dart, and Lancer.

Until recently Perfect Circle's service manager, author Jack Bryan is especially qualified to make the analysis contained in this article. A few months ago he was named general manager of Perfect Circle's newly created Speedostat Division.

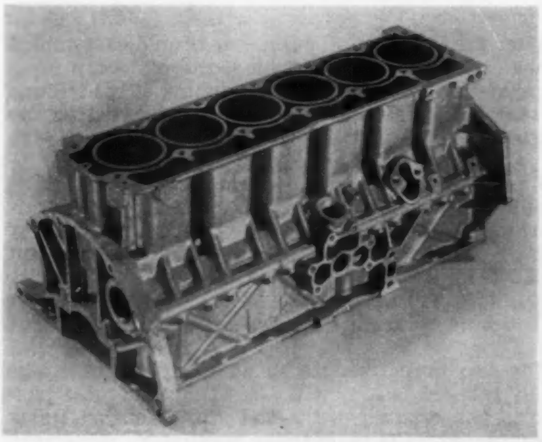
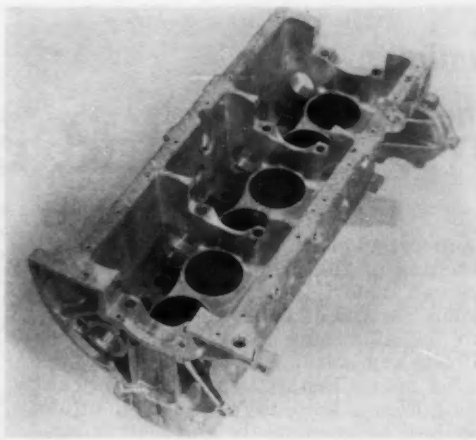


Fig. 5 — CHRYSLER Corp.'s aluminum engine also has "free-standing" bores and a cylinder block without a continous top deck — but in the Chrysler design, the barrels are not connected in pairs.



Fib. 6 — In Chrysler Corp's aluminum engine design, the crankshaft is supported by replaceable upper and lower cast iron main bearing caps.

example of obtaining volume on a major item to keep costs at a minimum.

Aluminum engine problems

So far, there seem to be no new "bugs" in the performance of U.S. aluminum engines that can be charged to the use of aluminum.

Corrosion prevention was a main consideration in selecting materials for blocks, water pumps, and gaskets. In most city waters, general corrosion of aluminum cylinder blocks and other aluminum components in the cooling system is no more severe than corrosion of cast iron and steel components. . . . In some cases, with proper inhibitors and care, the smooth-surface aluminum engines are more resistant to corrosion than are iron and steel.

So, the only special recommendation for taking care of aluminum engine cooling systems is: Use water pure enough to drink—and also a reliable inhibitor and alcohol or ethylene glycol type solution. (Buick cautions against use of salt solutions, such as calcium or magnesium chloride and sodium silicate. American Motors does not recommend alcohol-base antifreeze because of the 195 F thermostat used by American.)

When tightening bolts in aluminum, use of a torque-indicating wrench according to manufacturer's specifications is an absolute must. Overtorquing will cause the aluminum to flow and bulge in the cap screw boss area. This can result in improper mating of flat surfaces, misalignment of main

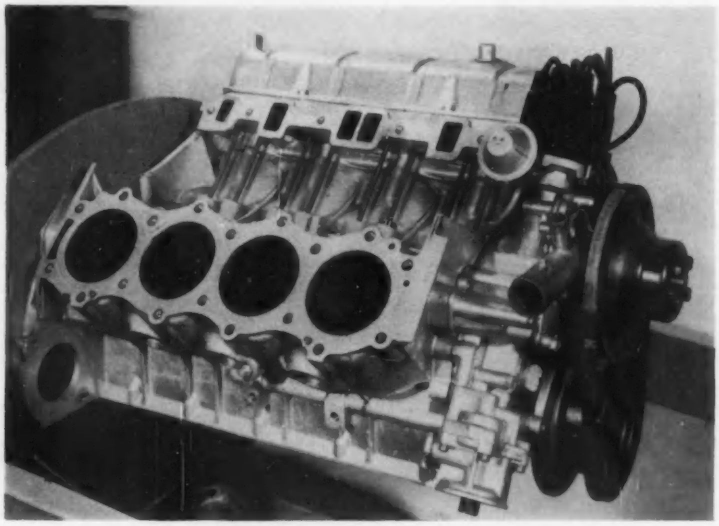


Fig. 7 — GENERAL MOTORS' aluminum engine design uses aluminum for all major components. . . . The same basic block is used for GM's three engines. Buick and Pontiac blocks are identical; Oldsmobile has additional cylinder-head bolts and water passages.

U.S. aluminum engines compared

. . . continued

bearing caps, incorrect bearing clearance, and crush. Uneven tightening of the cylinder head and main bearing bolts can distort the cylinder bores, causing compression loss and oil consumption.

Damage to the aluminum block threads can be prevented if bolts and bolt holes are cleaned and the bolts lubricated before installation. The lubricant recommended differs — some say use lube oil, others suggest a non-hardening lubricant and sealing compound. All cylinder head bolts should be torqued when the engine is cold. American Motors recommends rechecking after the engine reaches normal operating temperature.

It is easy to over-torque cap screws in aluminum. There are two reasons for this. One, the torque specifications for a given size cap screw in aluminum is approximately 30% less than for iron. Second, is a difference in the feel of the torque wrench. Aluminum gives a soft, mushy sensation as the cap screw is tightened. Occasionally a cap screw may seize and stop turning before the specified torque is reached. When this occurs, it is necessary to loosen the cap screw slightly and retorque.

The Buick and Oldsmobile oil pump gears are housed in the timing chain cover which also serves as the base for the oil filter. Whenever the oil pump, pump cover, or timing chain is disturbed, the teeth of the oil pump gears must be thoroughly covered with petroleum jelly. Otherwise, the pump may "lose its prime" and fail to pump oil as soon as the engine is started. (Engine rebuilders should include this operation in their engine overhaul procedure.)

After the Rambler oil pump has been disassembled or when a new one is installed, the oil pump must be primed before starting the engine. This is done by removing the relief valve plunger located on the outside of the engine and filling the pump with oil.

Since cylinder liners are permanently cast in the aluminum blocks, they are NOT REPLACEABLE as we think of wet and dry liners. In other words, they cannot be pulled out and a new liner installed. But THEY CAN BE REBORED. They shouldn't require reboring except after long service, however, because of the long wearing qualities of centrifugally cast iron.

The maximum oversize for which cylinders can be safely rebored is somewhat less than for most passenger car engines with cast iron blocks. Buick recommends 0.020 in. oversize maximum. American Motors and Oldsmobile recommend 0.030 in. Chrysler Corporation recommends 0.040 in. These specifications keep to a minimum the number of low volume oversize parts required to service the engines. The chamfer often machined at the top of the bores following the boring operation should be just large enough to permit free entry of the pistons and ring assembly. A large chamfer will reduce the crush area on the head gasket and this could lead to leakage.

Aluminum engines **can** be damaged beyond repair by careless handling. Gouges, dents, file marks, and hammer nicks inflicted by a careless repairman can put an engine into the scrap heap quicker than hard use.

The adaptability of aluminum and its alloys to modern labor-saving methods is being demonstrated. Aluminum as an engine material is accepted. Its full test and survival will depend upon the economics of manufacturing.

To Order Paper No. S312 . . .
from which material for this article was drawn, see p. 6.

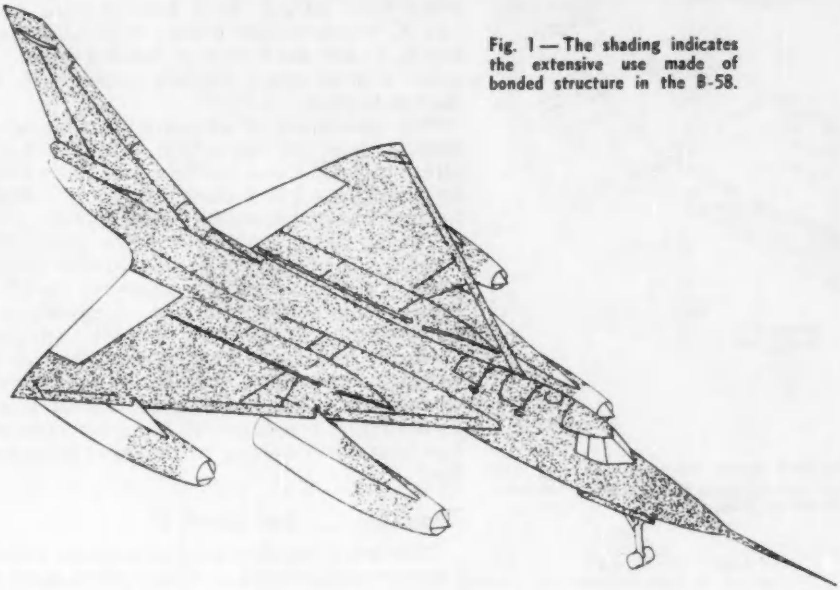


Fig. 1 — The shading indicates the extensive use made of bonded structure in the B-58.

Hustler is a bonded bomber

Based on paper by

L. M. Smith

General Dynamics Corp.

THE B-58 "Hustler" relies on metal bonding adhesives to a greater degree than any airplane in the history of aviation. Extensive use of such adhesives has given a unique airframe design which has greatly helped the aircraft capture several speed and endurance records.

Almost the entire surface of the aircraft is covered with adhesive bonded structure, as Fig. 1 shows. Only the elevons and aft portion of the nacelles do not use adhesives. Brazed stainless steels are needed in these areas because of the jet engine heat. The remaining areas, except for the glass reinforced plastic radomes, consist mainly of two types of aluminum bonded structure—"sandwich" panels and "beaded" panels.

Clean wing results

The entire outer skin of the wing, which is made up of "sandwich" panels, is attached by adhesives alone, without the aid of mechanical fasteners. Adhesive is used to transmit primary loads. The result is a clean wing with simplified spars of few pieces. The large size panels are installed with a minimum number of fasteners, making the wing smooth inside and out. The usual clips, gussets, stiffeners, and rows upon rows of rivets are gone. The clean appearance includes the leading edge.

An internal slug, or grid, is used in the wing "sandwich" panels, as Fig. 2 illustrates. The grid is efficient for load introduction and for panel splicing. No fasteners go through the honeycomb core area; all attach through aluminum. The grid also helps to minimize tooling. Pilot holes for attachment bolts are drilled into the plate and used to cut the grid, drill skins, and later to locate the understructure holes. The one-piece design of the slug simplifies manufacture and layup of the panel for bonding.

To simplify tooling, fabrication, and assembly, all wing sandwich panels were made one consistent overall thickness. This dimension is .580 in., and changing skin thicknesses are accommodated by varying the core thickness. Since a high percent of the total bending material is in the skin, there is a greater torsional stiffness than in the conventional wing having the same bending strength.

The Hustler's delta wing is a multispar design having no chordwise ribs as in conventional wing structure. However, chordwise members or bulkheads are located at such points as elevon, nacelle, and gear attach points. The use of multiple spar and double skin construction lends fail-safe features to the wing as several paths are provided for every load.

The spars which are used as fuel tank boundaries are designed for a minimum number of through-holes. The intermediate spars consist of a corru-

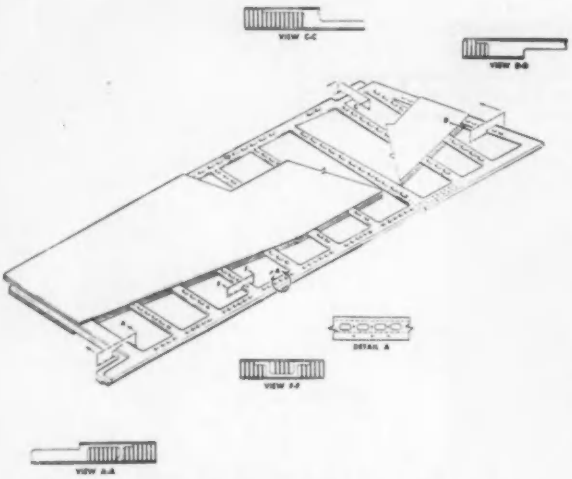


Fig. 2 — Cutaway of a wing panel reveals the grid. The wing skins have relatively little curvature and are made of 2024-T86. This same material has replaced 7075-T6 for use in the grid.

gated web attached to a horseshoe capstrip. The corrugated web is efficient in resisting fuel slosh pressures while it minimizes thermal stresses. The spars also serve as baffles in the large flat fuel tank. Both types of spar are shown in Fig. 3 and panel attachment details are shown in Fig 4.

In the fuselage area the surface skins are stiffened by use of beaded inner skins. Both skins are bonded together to form panels such as shown in Fig. 5. The beads flatten out at bulkheads to simplify bulkhead design and attachment. A scalloped doubler is used to reinforce these attach points. Later airplanes have some of the beaded panels replaced with sandwich panels, which require a minimum of tooling due to the use of wet layup fiberglass edge-members. Although both designs are considered shear panels, they carry significant fuselage bending loads.

The bonded sandwich panels are designed to be stable and not to fail by panel buckling. Failures are local and of the core shear instability type or the face wrinkling type. The stable design helps prevent premature bond failure, since a tendency to buckle creates a peel loading that could cause extensive bond damage. This is important because adhesives having high temperature capability become brittle at – 67 F. Bond failure, if it does occur, is not catastrophic in the B-58 panels. In most cases it is confined to a bay and the skin (and tank) are still intact.

The stable design also allows operation at high stress, with failing compression stresses actually above the yield stress of the material. Since yielding can take place without failure, the design stresses are not modified to account for thermal stress. Tests have demonstrated that a 260 F thermal gradient, caused by cold fuel against the inner skin and a hot outer skin, does not affect panel short time ultimate strength.

Separate adhesives are used for metal-to-metal and for skin-to-honeycomb core applications, since a single adhesive for both areas was not found. The metal-to-metal type is a nitrile rubber phenolic adhesive. It has adequate strength, and will resist creep and fatigue in a temperature range from – 67 F, which occurs during high altitude subsonic cruise, to the 260 F met in Mach 2 flight. Furthermore, it is an easily applied "tape" type, and is resistant to fuel.

The core-to-skin adhesive, an expoxy phenolic formulation, has the added ability to form a high strength fillet along the core cell walls with little or no pressure applied during bonding. The two adhesives have campatible curing cycles.

The core is a phenolic resin-fiberglass cloth honeycomb. A large factor leading to this choice was its ability to resist bonding pressures at 175 psi at a temperature of 350 F for 2 hr. A variety of other requirements for the core include: adequate shear strength and rigidity to resist internal fuel tank pressures as well as stabilize the sandwich facings to resist in-plane loads; retention of this strength to 260 F and resistance to creep for sustained loads; low heat conductivity to provide insulation for the fuel.

Trouble . . . but worth it

The metal bonding process imposes stringent fabrication requirements. Detail parts must be manufactured to close tolerance, bonding areas must be kept hospital clean, and comprehensive in-process inspection must be performed. Panel acceptance is based on three inspection procedures. The first is a nondestructive check for voids of all the bonded areas with an ultrasonic impedance device. The second check consists of small specimen tests cut from a test tab that is an integral part of each panel. Third, there is a destructive test of completed panels on a statistical basis that yields a 95% reliability with a 95% confidence level. Over 52,700 panels have been produced so far with an overall scrap rate of only 4%.

Has the extra effort spent on bonded structure been worthwhile? It would seem so, judging from a comparison with seven recent bomber airframes. The B-58 had the lowest percentage of gross weight taken up by structure—some 16.5%. This is all the more impressive considering the tough environmental conditions which the aircraft encounters.

Also important is the maintainability built into the structure. It has been said that the B-58 uses erector set assembly, in that it can be disassembled at the operational base. The large panels, which measure as much as 5 ft by 18 ft can be removed as easily as the small panels. The entire upper surface of the wing can be removed in little more than two days in order to rework or inspect the under structure. True, the thin skins used in the B-58 are more susceptible to minor damage than conventional gages, but repair is simple and effective.

The inherent stiffness of the bonded and brazed structure eliminates the panel flutter problems encountered with a more conventional structure. The rigid requirements for aerodynamic smoothness have been met with bonded structure with no extra effort in production. Sonic and cyclic fatigue resistance has been proved as well as the built-in fail-safe features. Aircraft downtime for panel repair has been negligible.

To Order Paper No. 420B . . .
from which material for this article was drawn, see p. 6.

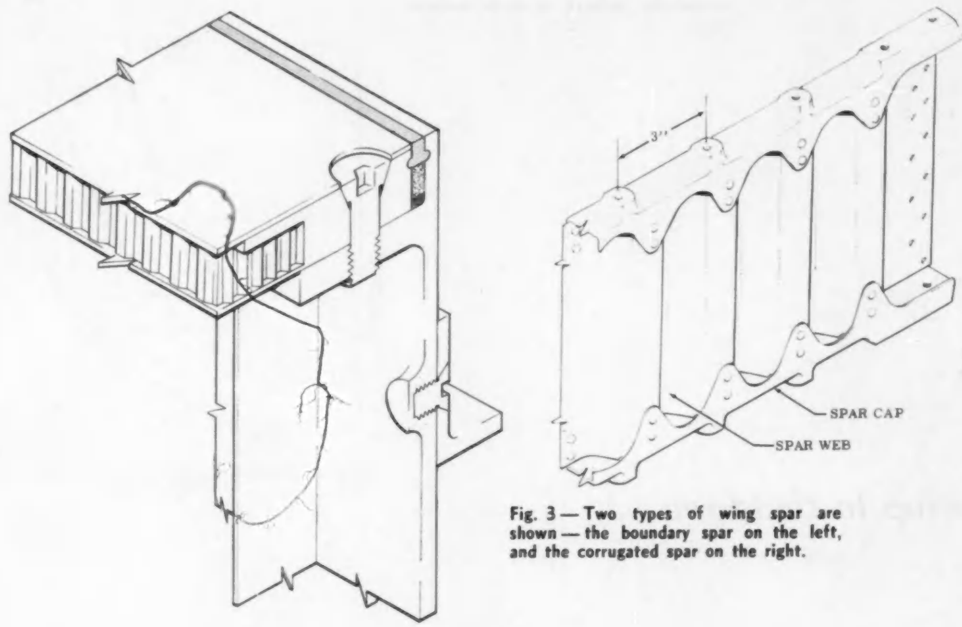


Fig. 3 — Two types of wing spar are shown — the boundary spar on the left, and the corrugated spar on the right.

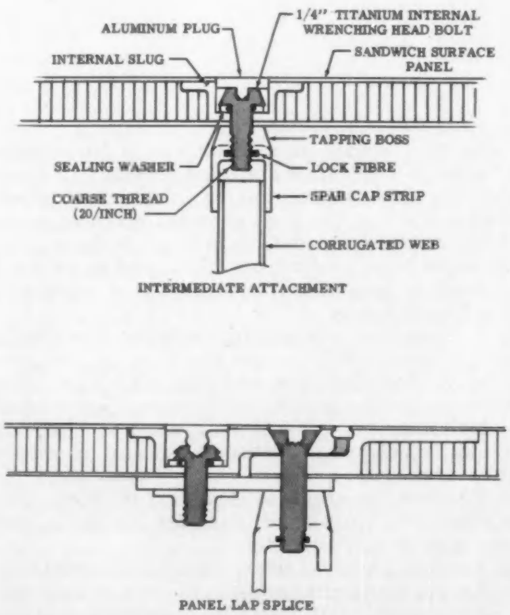


Fig. 4 — Detail shows how wing panels are attached. The lap splice introduces some eccentricity into the joint but the stiffness of the adjoining panel is enough to handle the resulting rotational moment.

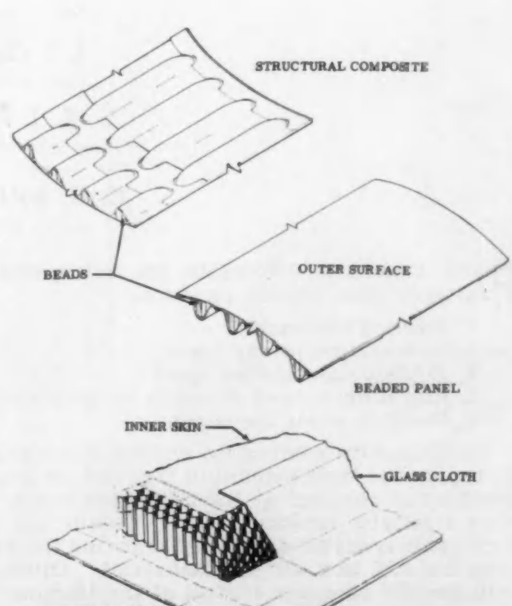
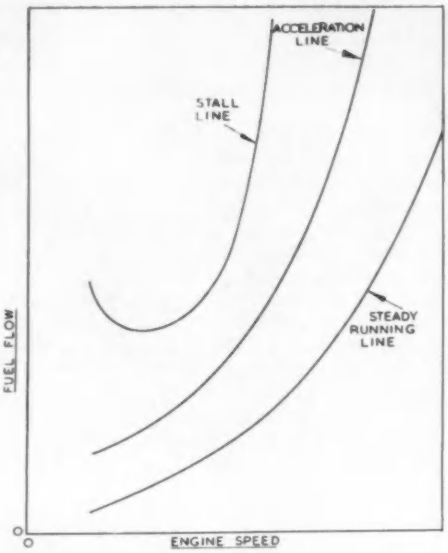


Fig. 5 — Two types of panel used in the fuselage structure.

Fig. 1 — Acceleration control should allow operation as close to the stall line as possible to avoid surge and provide maximum acceleration without excessive temperatures.



From startup to shutdown . . .

. . . gas turbines need

Based on paper by

J. S. Clarke,
Joseph Lucas, Ltd.

C. K. J. Price,
Lucas Industrial Equipment, Ltd.

and

C. H. Bottoms,
Lucas-Rotax, Ltd.

FUEL CONTROL SYSTEMS for automotive gas turbines must provide means for:

1. Starting the engine.
2. Accelerating to any speed.
3. Holding any selected speed.
4. Adjusting to load demands automatically.
5. Shutting down the engine.

To initiate the combustion process, it is necessary to supply the right amount of fuel and air into the combustion chamber at the right time and to provide a suitable ignition source. Usually the main fuel pump is engine driven and cranking the engine supplies fuel and air simultaneously. Often, this will provide adequate control of the starting fuel-air mixture. But, because fuel atomization is poor at normal cranking speeds, extra fuel must often be supplied. This can lead to excessively hot starts. One way to alleviate this condition is to provide power enough to get high cranking speeds. An electric starting motor will do the job. Once combustion pressure is reached, the gas generator will accelerate and fuel control is needed to prevent turbine inlet temperature from getting too high, and to prevent compressor surging — a consequence of excessive turbine temperature.

Fig. 1 shows the relationship between the steady running characteristic of the gas turbine, the permissible acceleration line, and the stall line. The acceleration control should permit operation as close to the stall line as possible to avoid surge and provide maximum acceleration without causing excessive temperatures.

Fig. 2 shows the effect of load on fuel flow. Obviously fuel flow must be adjusted for change in load if there is to be speed control.

Fig. 3 shows a typical speed governor characteristic with a 2% speed change from no load to full load. Two per cent control is about the maximum you can get with stability and still have a simple system.

In automotive applications inlet temperatures of - 60 to 120 F must be provided for and fuel requirements vary with the square root or the absolute inlet temperature. The effect of such variation is shown in Fig. 4 for an engine operating at a given load. The power output will, of course, be higher at lower temperatures. It is necessary that acceleration con-

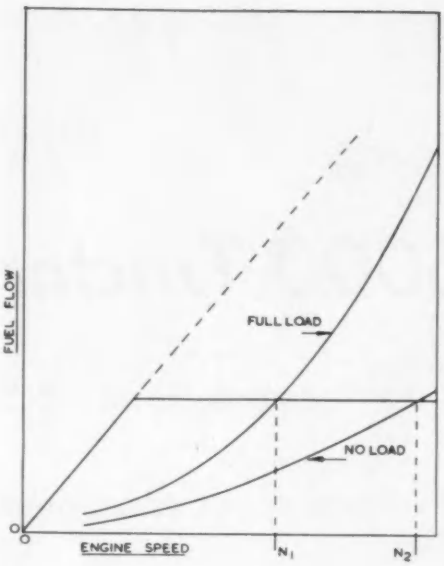


Fig. 2 — Speed control is provided by changing fuel flow with changes in load.

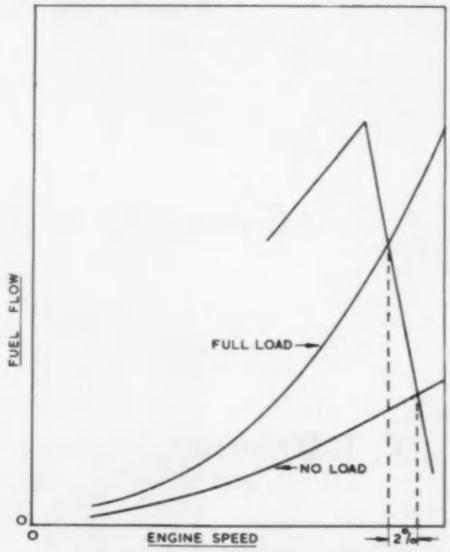


Fig. 3 — Typical speed governor holds speed to 2% change in going from no load to full load.

fuel control

trol be satisfactory over this range of inlet temperatures. For vehicles this control will have to be provided automatically.

Vehicles in certain parts of the world are called on to operate through a wide range of atmospheric pressures. In North America maximum altitudes of about 8000 ft are experienced, but in other parts of the world it is necessary to provide controls capable of operation to 15,000 ft. Here again acceleration control must meet the varying conditions.

One consequence of variations in ambient temperature and pressure is the possibility of excessive temperatures which could affect the safety and life of turbine blades and other components. A temperature control operating in the exhaust of the turbine is a must.

Shutting down the engine is normally achieved by a suitable shut-off cock, but means must be provided for evacuation of residual fuel in the manifold to avoid dribbling into the combustion chamber while still hot and to prevent possible coking of the combustion system.

There is a real need for provision of emergency shut-down protection as a safeguard against free-turbine shaft or transmission failures. A quick-acting trip can protect against a rapidly accelerating free turbine and prevent bursting of the wheel.

To Order Paper No. 398D . . .
from which material for this article was drawn, see p. 6.

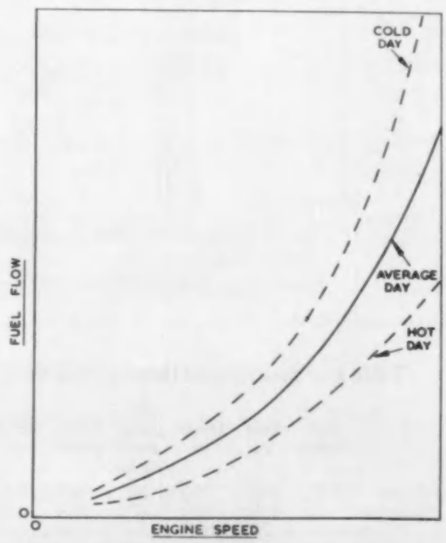


Fig. 4 — Fuel requirements vary with ambient temperature in steady running engine.

New Ford 6000 Tractor

• Horsepower up to 76.5

• Greater use of power control and power accessories

Based on paper by

C. T. O'Harrow, C. B. Richey and B. G. Burnside

Ford Motor Co.

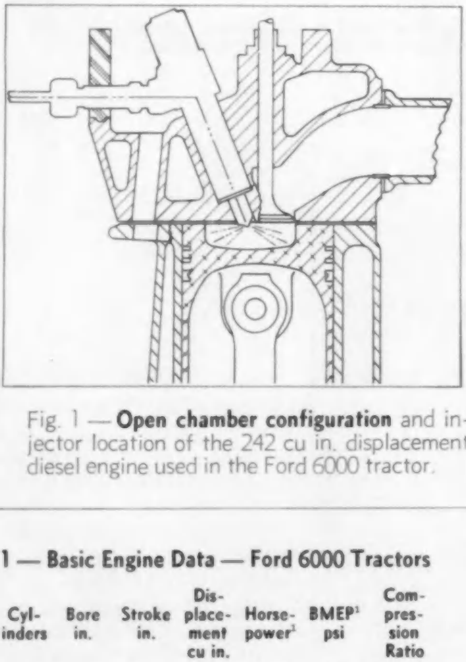


Fig. 1 — **Open chamber configuration** and injector location of the 242 cu in. displacement diesel engine used in the Ford 6000 tractor.

Table 1 — Basic Engine Data — Ford 6000 Tractors

	Cylinders	Bore in.	Stroke in.	Displacement cu in.	Horsepower[1]	BMEP[1] psi	Compression Ratio
Diesel	6	3.63	3.90	242	76.5	104	16.5/1
Gasoline	6	3.62	3.60	223	79.3	117	8.4/1

[1] Observed hp at 2400 rpm — no fan, air cleaner, or muffler — 87 F air temperature – 29.10 in. hg barometer (approximately).

THE NEW FORD 6000 series tractors are the largest and most powerful ever built by the company. Increased use of power control and provision for the adaptation of power to mounted, trailed, and pto-driven implements further extend overall capacity of the tractors.

Powerplant

Six-cylinder diesel or gasoline engines are available in the 6000 tractors (Table 1). Fig. 1 shows the open-chamber configuration and the injector location of the diesel. The desired swirl is obtained by using siamesed inlet ports at 1-2 and 5-6 cylinders.

Fig. 2 shows performance curves for the diesel. The maximum horsepower at rated speed of 2400 rpm is 76.5 at 0.455 lb per bhp-hr. Maximum engine torque is 187 ft-lb at 1400 rpm. The torque curve is quite flat and at 1200 rpm is 183 ft-lb. Torque at rated speed is 165 ft-lb. This means that the torque variation in the operating range 1200–2400 rpm is 10% — a desirable characteristic when coupled with the characteristic of accessory losses and used in conjunction with the Select-O-Speed transmission. The minimum brake specific fuel consumption at full fuel setting is 0.425 lb per bhp-hr at 2000–2200 rpm.

The 6000 gasoline engine performance curves are similar to those shown for the diesel. The maximum observed horsepower of the gasoline engine at rated speed of 2400 rpm is 79.3 at 0.510 lb per bhp-hr. The maximum engine torque is 186 ft-lb at 1650 rpm. Torque at 2400 rpm is 173 ft-lb. This means that the torque buildup is 7.5% in the operating range of 1650–2400 rpm. The minimum brake specific fuel consumption is 0.505 lb per bhp-hr at 2100 rpm.

Transmission and power takeoff

The 6000 tractors use the Ford Select-O-Speed transmission (Fig. 3) which provides on-the-go

shifting, under full load, throughout the full range of ten forward and two reverse speeds. Recent revisions to this transmission provide increased power capacity for the new tractors.

The 6000 Select-O-Speed transmission provides the highest maximum reduction-to-minimum reduction of any standard agricultural tractor. This ratio is 15.3/1. This means that low rates of travel can be obtained with high pto horsepower availability without sacrificing high road speeds for moving the tractor from job to job.

The major differences between the Select-O-Speed transmission used on the 6000 tractors and that used on previous models are:

1. Heat sink capacity of all clutches has been increased by using thicker clutch plates and more plates.
2. Space for changes such as those with the clutches has been obtained by moving the fixed reduction, rear planetary set, from the transmission to the rear axle assembly.
3. Free-wheeling or coasting in first, second, fifth, sixth, and ninth gears has been eliminated by replacing the one-way clutch, used in the first planetary set, with a power operated disc clutch. This enables engine braking in all gears for downhill operations with pto-driven tools.
4. Transmission oil can circulate through a heat exchanger in the radiator bottom tank. This

General Specifications of the Ford 6000 Tractor

Observed pto hp at 2,400 engine rpm	66.86 gasoline 66.17 diesel
Observed drawbar hp at 2,400 engine rpm	61.09 gasoline 61.31 diesel
Drawbar pull (standard tires weighted to full capacity — concrete surface), lb	7,235 gasoline 7,245 diesel
Shipping weight with standard equipment (dual front wheels), lb	6,800 gasoline 6,980 diesel
Wheelbase — single or dual wheel adjustable front axle, in.	95 103.5
Height at top of hood, in.	68
Rear tire size — standard optional	15.5–38 18.4–34
Hydraulic lift capacity, lb	4,880

New Ford 6000 Tractor

. . . continued

provides better control of the engagement time-interval on clutches by stabilizing oil temperature and oil viscosity.

The pto system is of the independent control type and is partially contained within the transmission (Fig. 3). It is completed in a two-speed gear box at the rear of the rear-axle assembly. The part within the transmission provides a basic 1000 rpm pto speed drive at either of two engine speeds, 2225 or 1730 rpm. The gear box at the rear provides a straight-through drive at 1000 rpm pto speed, or provides an alternate reduction to the 540 rpm standard.

In addition, 1000 rpm pto drives are provided at

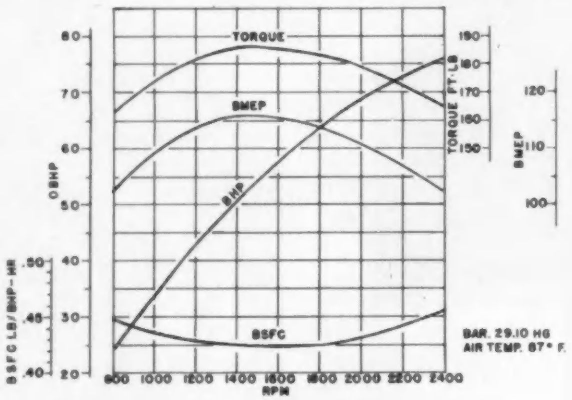


Fig. 2 — **Performance curves** of 242 cu in. displacement diesel used in the 6000 tractor.

the right-hand and left-hand sides of the tractor. A ground speed pto drive can be engaged to the rear pto shaft. The ground speed drive establishes a relationship between pto shaft revolutions and inches of tractor movement. Depending on the ratio selected at the rear pto gear box, the relationship is either one pto shaft revolution per six inches of tractor travel or one pto shaft revolution per eleven inches of tractor travel.

Thus, the pto reaches beyond the systems generally employed in agricultural tractors by providing:

1. Dual pto drives at 540 and 1000 rpm to permit attachment to both 540 and 1000 rpm implements.

2. Drives of 540 to 1000 rpm at a high engine rpm to give maximum pto horsepower when needed, and at a low engine rpm to provide the most economical operation when pto power requirements are low.

Hydraulic system

The 6000 tractor is equipped with a closed-center hydraulic system which operates the rear lift, remote cylinders, and brakes (Fig. 4). The system is powered by a pump which delivers 2.2 gpm at 2000 rpm (8.4 cu in. per sec) and has an accumulator for storing the hydraulic energy. Peak storage pressure is 2300 psi with a recharge cut-in at 1950 psi.

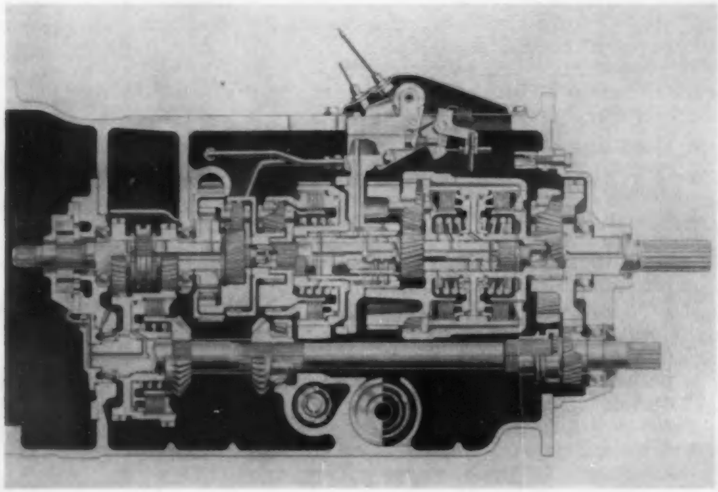
The closed-center and accumulator system are used on the 6000 tractor because:

1. Multiple circuits can be accommodated without using flow-control valves.

2. Smooth feathering action is obtained at all control valves.

3. Peak mechanical input requirements are only 3.7 hp compared to a maximum hydraulic output of 12 hp. A direct pumping system would require a peak input of 15 hp for equivalent peak output horsepower. With such low input horsepower needs, it isn't important that the

Fig. 3 — **Select-O-Speed transmission** provides on-the-go shifting, under full load, through ten forward and two reverse speeds. Recent revisions to transmission provide greater capacity.



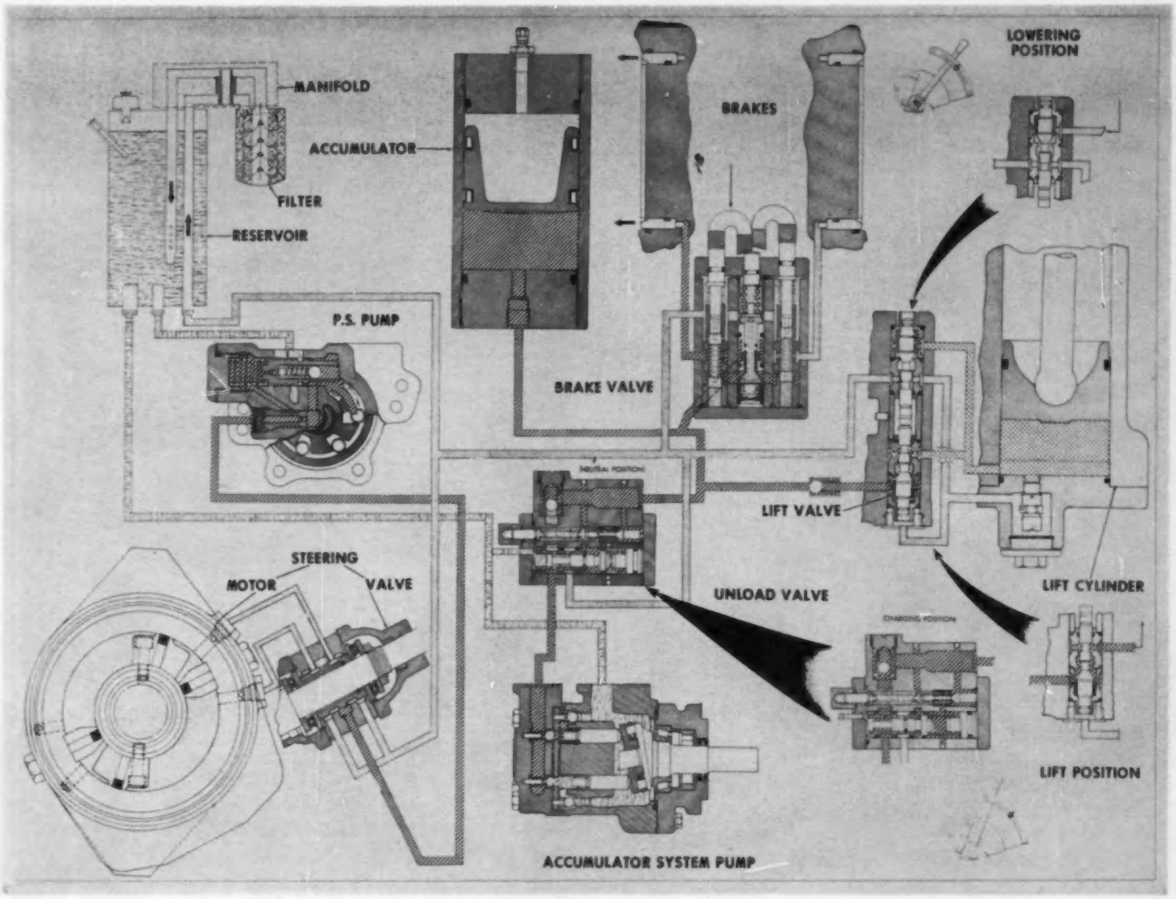


Fig. 4 — **The 6000 tractor features** a closed-center hydraulic system which operates the rear lift, remote cylinders, and brakes.

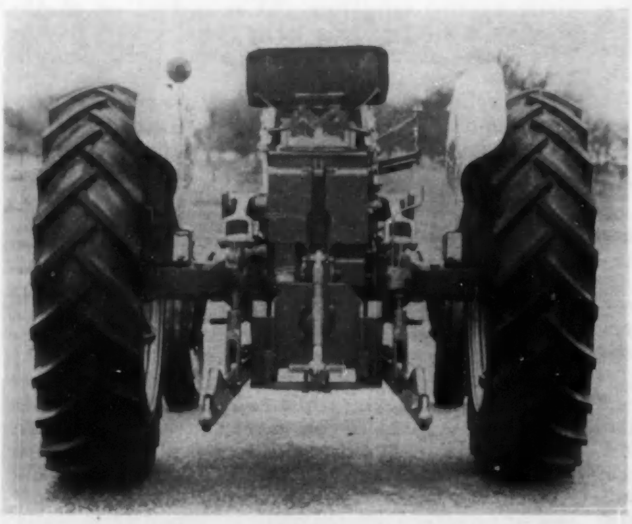


Fig. 5 — **Hydraulic lift assembly** is contained within a single housing mounted on the rear axle housing.

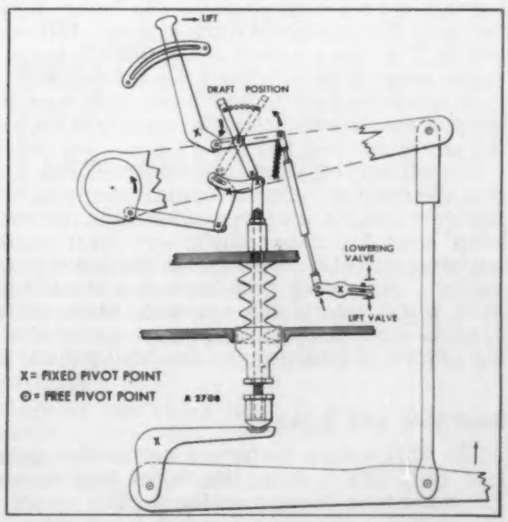


Fig. 6 — **Lift control linkage.** Draft sensing mechanism connects through lower links of three-point hitch system.

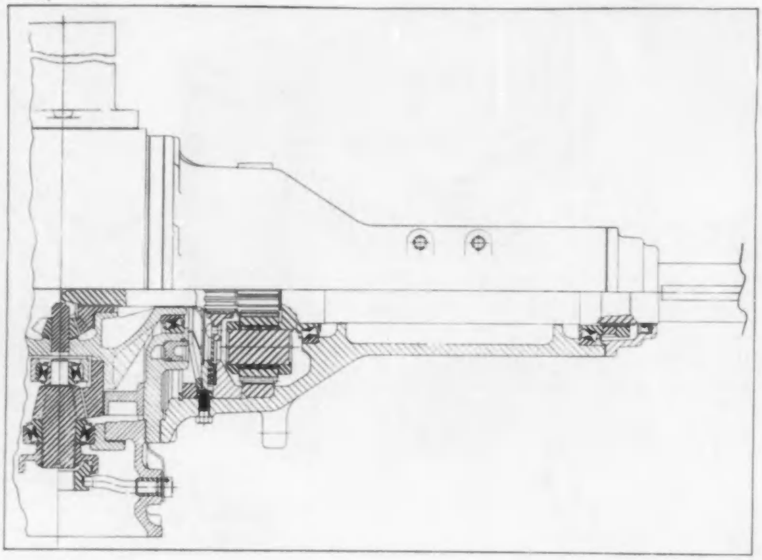


Fig. 7 — **6000 tractor features** new double-reduction rear axle. Center and left-hand axle housing sections are shown.

New Ford 6000 Tractor

. . . continued

hydraulic horsepower demand may come when the engine is operating at near maximum power to maintain drawbar or pto loads.

The hydraulic lift assembly is contained within a single housing mounted on the rear axle housing (Fig. 5). The lift is operated by a 3.87-in. diameter piston which has a 4.62-in. stroke. The lift connects through a rear rock shaft to the lower links of a Category II three-point hitch system. Lift capacity is 4,880 lb at the rear end of the lower links, and the power range is 24 in. The lift rods can be attached to a rearward hole in the lower link, and in this parallel construction the lift capacity is 5400 lb and the power range is 20.7 in.

The lift control linkage is shown in Fig. 6. Note that the draft sensing mechanism connects through the lower links of the three-point hitch system. The hand lever for either implement draft control or implement position control is at the top of the illustration. Just below this lever is a smaller second lever which selects the alternate draft control or position control. Intermediate positions give varying degrees of sensitivity to the draft control action.

Rear axle and brakes

The 6000 tractor features a new double-reduction rear axle. Fig. 7 shows the center housing and the left-hand axle housing sections. The center housing section contains the spiral bevel drive pinion and the ring gear set conventionally mounted. The four-pinion differential gear set is contained in the differential case. The axle housing section contains the second reduction gear set, which is a planetary set of 4.92/1 ratio, and the rear axle shaft and power brake.

The sun gear of the planetary gear is driven by the differential side gear and it in turn drives the three planet pinions. The planet pinion carrier is forced integral with the forged axle shaft. The ring gear is pressed into the axle housing and locked against movement by three dowels. The planetary gear set has straight spur gear teeth. Planet gears are carried on double roller bearings. Hardened steel thrust washers are used at the ends of the planet pinions. The planet pinion shafts have a shoulder which lock them against axial movement and are pressed in to avoid rotation. The rear axle shaft bearing adjusting nut is carried on a split sleeve which locks in a large radial groove on the axle shaft outside diameter to avoid stress concentrations.

The wet disc brake components are enclosed at the inner end of the axle housings. Brake discs are loosely splined to the sun gear shafts. The brake back plate is locked into the axle housing. It has eight slots on the inside face which engage lugs at the outside diameter of the pressure plate.

An annular brake piston, carried in the differential bearing retainer, is hydraulically actuated under control of the brake valve. The piston applies force through a modified Belleville spring. This spring returns the brake piston and releases the brake.

The double reduction axle provides high reduction ratio and high torque capacity in a comparatively small space which can be arranged to cause minimum interference with crops and with other tractor components such as rear linkage, hydraulic lift, rear pto shaft, and drawbar.

To Order Paper No. 391C . . .
from which material for this article was drawn, see p. 6.

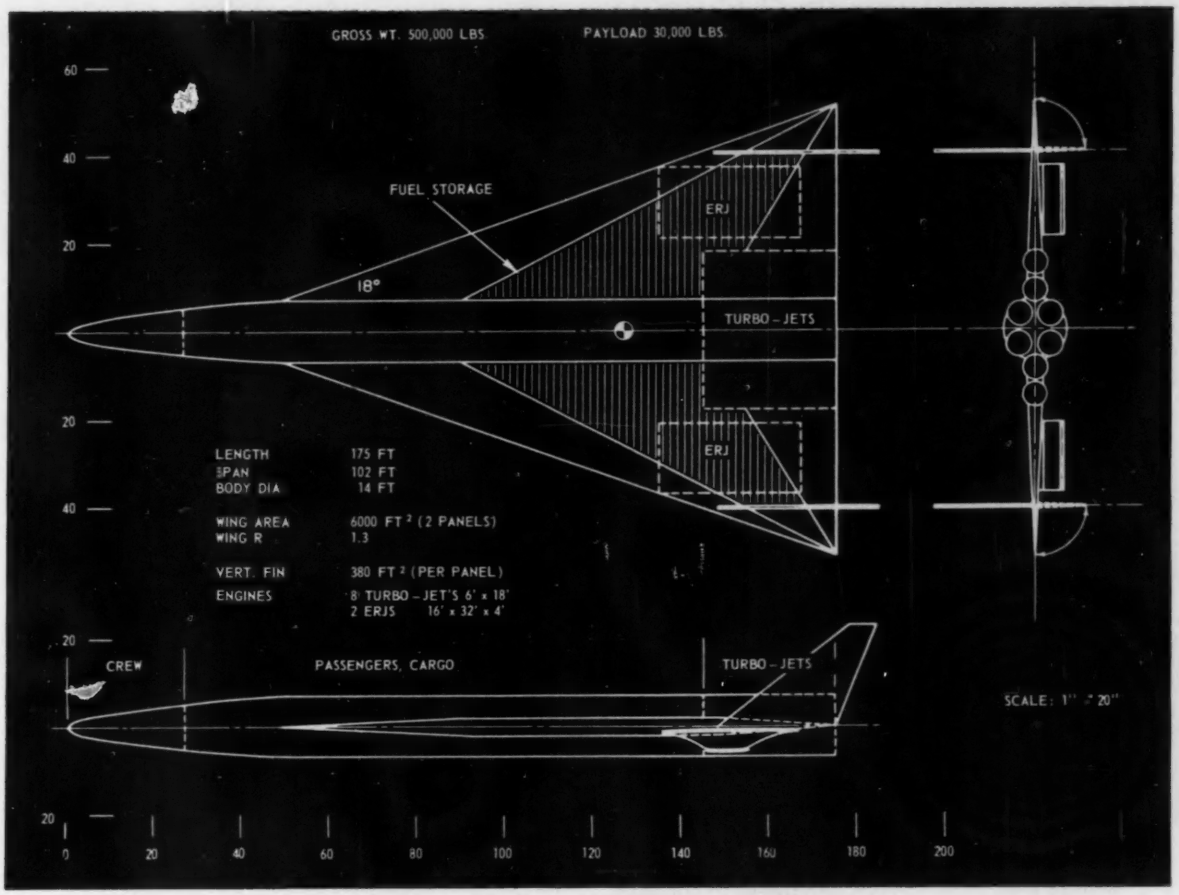


Fig. 1 — **Hypersonic transport** might have this basic configuration.

Mach 7 transport waits in the wings

Based on paper by

G. J. Pietrangeli and E. V. Nice

Applied Physics Laboratory, The Johns Hopkins University

IF YOU CAN'T WAIT to see what the second generation of faster-than-sound transports will look like, glance at Fig. 1. Such an aircraft, a Mach 7 design, may well be the focus of attention once the Mach 2–3 transport becomes operational.

Of course, to make it worth the economic and technical difficulties involved, the hypersonic craft would have to offer a sufficient improvement in trip time. It could not hope to compete over ranges less than 3000 nautical miles because the take-off and landing procedures would consume too high a percentage of the total time. A preferable non-stop range would be more like 6000 nautical miles. Its payload would probably have to be around 30,000 lb, which is comparable to current subsonic jet transport payloads.

Because of the broad Mach number range two propulsion systems would be needed. Operation at the lower speeds, in the Mach 0–3.6 range, would utilize turbojets; and ramjets would be used from Mach 3.6–7.0. Mach 7 flight was specified because the overall efficiency of the ramjet is a maximum in the vicinity of that speed.

The delta planform was chosen for its favorable aerodynamic characteristics, which include: high

lift/drag ratios at high speed; minimum center of pressure travel with Mach number; and alleviation of aerodynamic heating problems by virtue of the highly swept wings. Besides, this configuration is relatively compact and has good structural integrity and aeroelastic characteristics. Satisfactory dihedral effects can be obtained by drooping the wing tips at high speeds.

Propulsion

Probably the most intriguing feature of the proposed transport design is that of lift augmentation via the ERJ (external expansion ramjet) engines. Lift augmentation is helpful to the extent that it can enhance the *L/D* ratio without introducing drag. In the usual case, where lift is derived solely from

Insulation burdens

Based on paper by

Thomas A. McCarty and Ann C. Weingartner

Applied Physics Laboratory, The Johns Hopkins University

RAMJET propulsion at sustained speeds requires careful consideration of the engine cooling problem. At Mach 7 cruise, the external expansion ramjet is subjected to destructively high temperatures, from which it must be protected.

The range of surface temperatures is shown in Fig 1. The outer surface of the engine cowl does not require cooling because the equilibrium wall temperature at $M = 7.0$ and 100,000 ft altitude is approximately 1100 F. The internal engine structure, though, is subject to the total temperature of the air and obtains no relief by thermal radiation to the atmosphere. It must be protected if it is to be maintained at a temperature no greater than 1200 F.

This can be done by using a protective layer of solid insulating material, and absorbing the associated heat transfer by vaporizing water. Unfortunately, extremely high temperature insulators are also high in weight and conductivity. Low weight and low conductivity are limited to relatively low temperature operation.

A promising low weight insulating material in fibrous potassium titanate, which is good up to 2200 F. For higher temperatures, either zirconium oxide or pyrographite could be used.

Fig. 2 presents another concept in insulation which can potentially decrease the insulation weights necessary to cope with high surface temperatures. This insulation is in the form of shingles which are inclined at a small angle to the surface so that the conducted heat must travel a long path through the strip material. In addition to the conduction through the strips and the air space, there is radiant transfer between surfaces 1 and 2. The angle of stagger holds this to a minimum by giving these surfaces less of a view of each other. Another aid in reducing the amount of radiation is to coat the face of the cooler surface with platinum. This results in a significantly lower value of emissivity at that surface since, for zirconium oxide, emissivity increases with decreasing temperature.

Weight comparison

For the two ramjets there are 868 sq ft of internal duct area, 410 sq ft of diffuser and external compressing surface, and 350 sq ft of external throat and exit nozzle surface. Protecting these surfaces by using a solid layer made up of zirconium oxide and potassium titanate results in requirement for 30,000 lb of insulation plus water. Using a solid layer of pyrographite and potassium titanate yields a total weight of 18,500 lb. Roughly one-half of each of these weights is the water heat sink required.

Using shingles of zirconium oxide having platinum coated lower surfaces gives a total weight requirement of 31,000 lb. For surfaces like the diffuser and exit nozzle, which are at lower temperatures, half of the insulation weight is water. The high temperature surfaces use 80% water in their insulation weights. Therefore, about 75% of the total insulation weight is water. When these shingles are used only where the surface temperatures are above 2200 F, and solid potassium titanate is used below 2000 F, the total weight of insulation is 27,500 lb. Again, roughly 75% of this weight is water.

The development of materials capable of withstanding high temperatures, while evincing low weights and thermal conductivities, would be a great improvement. An equally important break-through would be the development of more effective means of absorbing or rejecting high heat transfer rates. Also, anything that reduces the surface areas exposed to excessively high temperatures helps reduce the insulation and water requirement.

To Order Paper No. 427D . . .
from which material for this article was drawn, see p. 6.

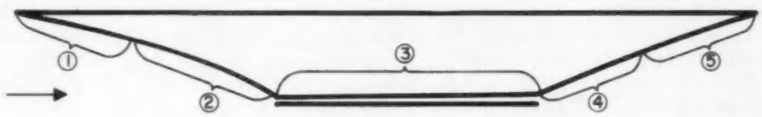
the lifting surfaces, the lift force has a component in the windward direction.

This drag component increases with angle of attack, and is commonly referred to as "drag due to lift." Use of lift augmentation does not imply that clean aerodynamic design is no longer important; for even if the entire weight of the plane were supported by life augmentation, there would still be zero lift drag to contend with.

Lift augmentation can be effected in several ways, such as, centrifugal force, tilting the engines, burning under the wings, and the like. The magnitude of the augmentation, if it comes from the engine, is constrained by the requirement that thrust equal drag. The engine is so efficient in thrust that its size together with its inherent lifting potential contributes only 12–13% to L/D. Whatever the ERJ contribution to L/D ratio is, it is paid for in increased engine weight and a penalty in fuel specific impulse.

The external expansion ramjet design, shown schematically in Fig. 2, was chosen for two reasons;

Mach 7 ramjet



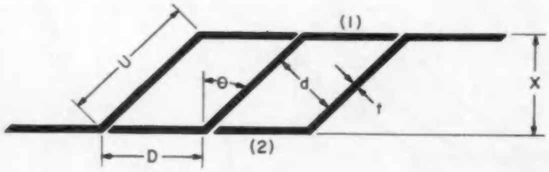
① ~ INITIAL WEDGE SURFACE
② ~ EXTERNAL COMPRESSION
③ ~ STAGNATION
④ ~ THROAT SURFACE
⑤ ~ NOZZLE EXIT SURFACE

EQUILIBRIUM WALL TEMPERATURES

M = 7.0 ALTITUDE = 100,000 FEET

REGION	T_{w_e} (°F)
1	1,500
2	1,800
3	3,500
4	3,850
5	1,800

Fig. 1 — **Equilibrium wall temperatures** of the external expansion ramjet.



PARAMETER VALUES

θ = 85°
t = .05 IN.
d = .20 IN.
D = 2.295 IN.
U ~ VARIABLE
X ~ VARIABLE (SHINGLE HEIGHT)
(1) ~ HOT OUTER SURFACE
(2) ~ COOLER INNER SURFACE

Fig. 2 — **Schematic** of shingle insulation layer.

Mach 7 transport waits in the wings

. . . continued

first, to combat the high nozzle temperatures (flame temperatures in excess of 5000 R are anticipated). The short cowl and half nozzle expansion design help alleviate this problem through effective radiative cooling. Second, the use of half nozzles yields a certain amount of lift from the high pressures acting over the nozzle section.

The ERJ's are located beneath the wings. When not in use, the compression and expansion ramps are retracted to minimize drag.

Preliminary studies show that reasonable ERJ sizing can be achieved to accomplish Mach 3.6–7.0 acceleration. This objective, it seems, can best be met by using a variable geometry diffuser with complete mass capture. The highest possible pressure recovery compatible with this design is to be used throughout climb and acceleration.

The turbojets used for the first phase of flight are

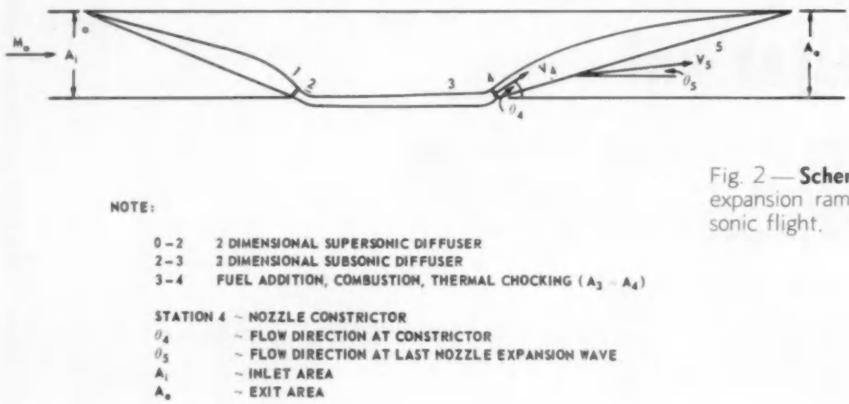


Fig. 2 — **Schematic** of an external expansion ramjet used for hypersonic flight.

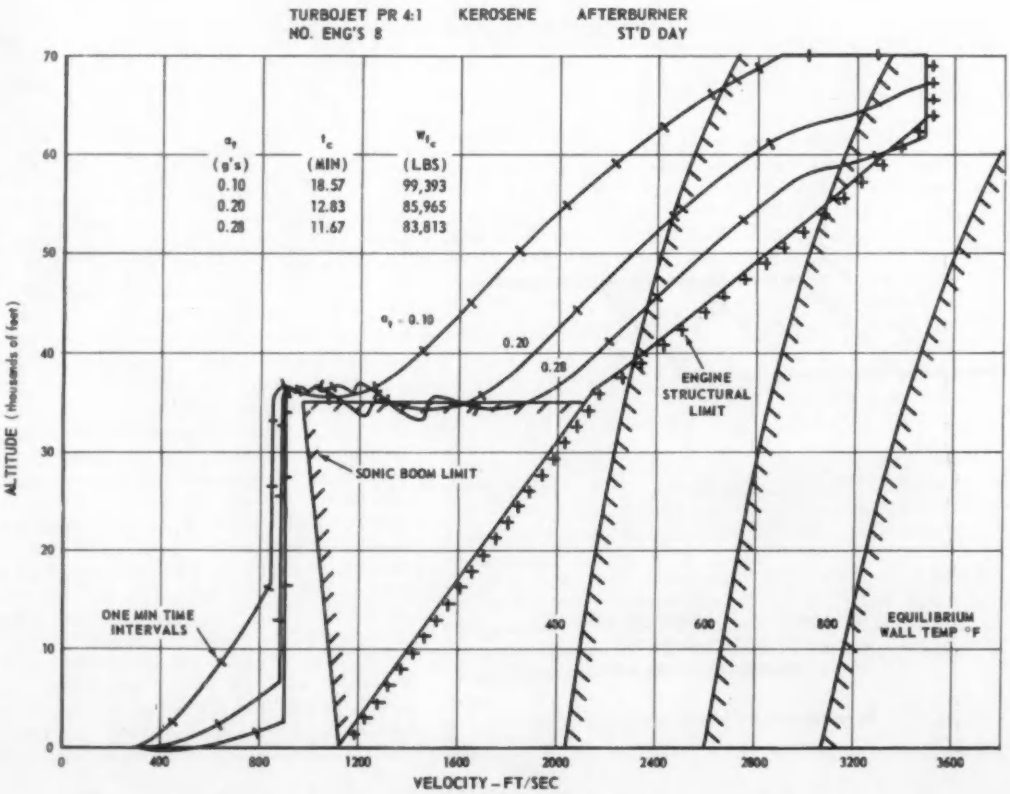


Fig. 3 — **Climb trajectory** of the hypersonic transport in the Mach 0-3.6 speed range.

assumed to use a 5-stage axial flow compressor with a sea level static pressure ratio of about 4:1. All are fed through retractible two-dimensional scoop diffusers at the rear of the fuselage and rear underside of the wings.

Acceleration time

Since a Mach 7 transport must offer a sufficient trip time improvement over, say, a Mach 4 transport, minimum climb and acceleration time are essential. Two other important variables are climb fuel and climb range. The principal design parameters used to achieve the objective are the maximum tangential acceleration, a_t, that is called for, the number of turbojet engines used, and the gross weight at take-off.

The a_t chosen for the initial phase of the flight, where the turbojets are used, will have a great bearing on fuel consumption. Simple considerations of induced drag and work required to lift the craft to its terminal altitude suggest that acceleration ought to be done at as low an altitude as possible. (Ideally, acceleration to the terminal velocity of Mach 3.6 ought to be done at sea level; followed by a climb to the terminal altitude). To effect acceleration to Mach 3.6 at lower altitudes higher values for a_t would have to be used. Obviously, though, there are limits to what speeds can be tolerated at specified altitudes. Sonic boom imposes one such restriction, and so does the engine structural limit. From the safety viewpoint, high velocities during the beginning of climb, brought on by high values of a_t, are also undesirable.

Here is how the climb and acceleration were programmed in this study. At the end of the take-off ground run a specified a_t is called for and held until Mach 0.8 is achieved. At this point, in order to avoid the objectionable effects of sonic boom, the tangential *g*'s are reduced to zero while the airplane climbs to 36,000 ft. Then the initially specified a_t is resumed. If the thrust during this transonic acceleration is marginal or deficient the plane can dive and use gravity to maintain the a_t called for. If the altitude drops below 34,000 ft due to this procedure, a_t is reduced systematically to permit regaining the lost altitude. Then a_t is systematically worked up to its initially specified value. The trajectory is continued until Mach 3.6 is reached at 70,000 ft and $a_t = 0$. In this last phase the switching from turbojet to ERJ's is accomplished.

Sample trajectories of this type are shown in Fig. 3, for a configuration having 8 turbojet engines. The climb times and fuel consumptions for the specified accelerations are also shown.

For the Mach 3.6–7.0 phase of the flight a specified acceleration is maintained until Mach 7.0 is achieved. If that occurs below 82,343 ft 0 *g*'s are called for until this altitude is reached. Above this altitude, it is necessary to accelerate again because of the increase in sonic speed. If the thrust is inadequate to attain Mach 7 by 100,000 ft, which is the start of the cruise altitude, acceleration is continued in horizontal flight until Mach 7 is reached. This phase of flight also has a structural limitation placed on the magnitude of a_t; imposed by the equilibrium wall temperatures that occur. Sample trajectories for this portion of flight are given in Fig. 4 along with climb time and fuel consumption data.

The overall picture, from Mach 0-7, regarding climb time, climb fuel, and climb range is shown in Fig. 5. Two cases are dealt with; an 8 and a 10 turbojet configuration. Evidently, the total climb time falls off rapidly with increasing a_t, until a_t is approximately 0.2 *g*. Little is gained by going to higher accelerations.

Climb fuel consumption also points to a choice of

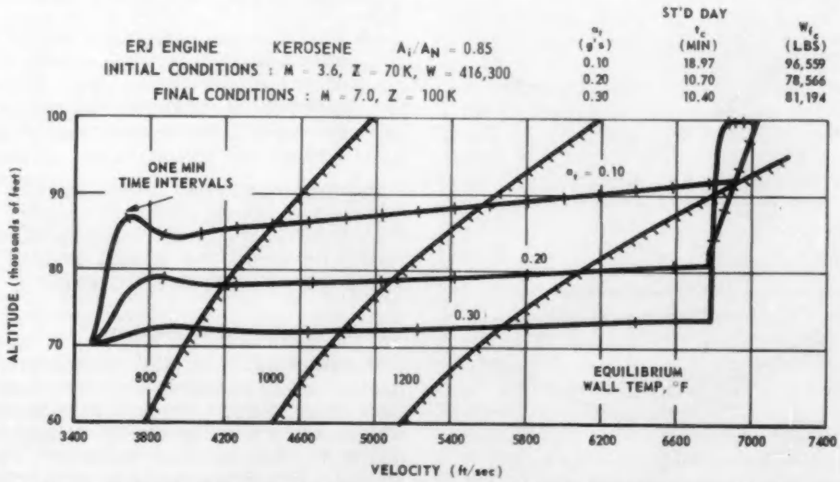


Fig. 4 — **Climb trajectory** of the hypersonic transport in the Mach 3.6-7 speed range.

Mach 7 transport waits in the wings

. . . **continued**

$a_t = 0.2\ g$ since greater accelerations are accompanied by an increased fuel consumption. This happens because the higher accelerations cause Mach 7 to be reached quickly, and at a relatively low altitude. The trajectory is characterized by a short time climb to 100,000 ft during which the Mach number falls below Mach 7. A long, fuel consuming, acceleration flight time at this altitude is then needed to regain Mach 7. As for the total climb range, it diminishes rapidly as a_t increases up to $a_t = 0.2\ g$. Beyond that point there is only a slight increase in climb range with increasing a_t, for the same reasons related to the behavior of the climb fuel curves.

An a_t of 0.2 appears to be best, then, because it avoids certain undesirable trajectory (such as excessive speed at low altitudes and limit oscillations through the transonic range), and gives good climb time and fuel consumption. While the $a_t = 0.2\ g$ trajectory is near optimal, the overall fuel consumption (approximately 160,000 lb) proved too high for the 500,000 lb vehicle to achieve the desired 6000 nautical mile range.

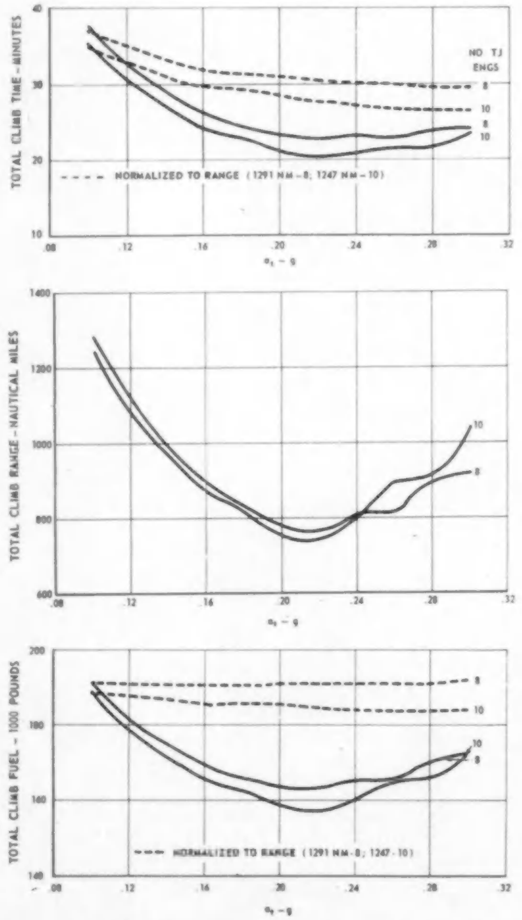


Fig. 5 — **Overall climb time,** climb range, and climb fuel, as a function of tangential acceleration.

Optimized trajectory

Further optimization is deemed possible, especially if the boundary constraints are relaxed. To demonstrate, three trajectories were computed for the turbojet flight phase for a 500,000 lb configuration with 8 turbojets. They are shown in the altitude-velocity plane in Fig. 6 and are characterized as follows:

Type (a) — Employs an optional nominal tangential acceleration of 0.2 g and satisfies the sonic boom and engine structural limit boundaries.

Type (b) — Does not use the sonic boom limit but is constrained to the engine structural limit altitude-velocity curve.

Type (c) — Duplicates Type (a) to 36,000 ft — followed by a horizontal flight phase until the engine structural limit is reached. The trajectory is then constrained to the engine structural limit.

The performance data at the top of Fig. 6 indicate that significant improvements in climb time and climb fuel are achieved with the Type (b) trajectory. Practically speaking, this trajectory could only be used over water, in boat-free areas. For inhabited land areas trajectory Type (c), showing moderate improvements in climb time and climb fuel, is most attractive. It also avoids the transonic range limit oscillations of trajectory Type (a).

For a more meaningful comparison of the trajectories a normalization with respect to range is required. Further, a broader examination would involve treating the number of turbojets as a parameter. Such a study was made, and showed that:

- The greatest ranges are always achieved with trajectory Type (a) and the least with Type (b), regardless of the number of turbojets.
- Significant savings in time result from flying trajectory Type (b) . . . with very little advantage in trajectory Type (c) over (a).
- There is an optimum number of engines which should be used, which is a function of trajectory type. Also, for a specified number of engines, trajectory Type (a) generally insures minimum fuel consumption.

Reasons other than minimum time to climb might dictate the actual choice of number of engines for the 500,000 lb transport. A minor climb time penalty might be worth the weight savings and increased reliability of having fewer engines.

Climb, cruise, and descent

Considering, now, the complete profile, the important thing to watch is overall range performance. The climb range increases with increasing take-off weight from a value of 780 nautical miles at 500,000 lb to 1930 nautical miles for 700,000 lbs, when $a_t = 0.2$. The cruise range is, of course, dependent on the fuel available for cruise. In turn, the amount of cruise fuel available depends upon how much weight must be allotted to thermal insulation and cooling of the ERJ engines, and to fuel reserve. Lift aug-

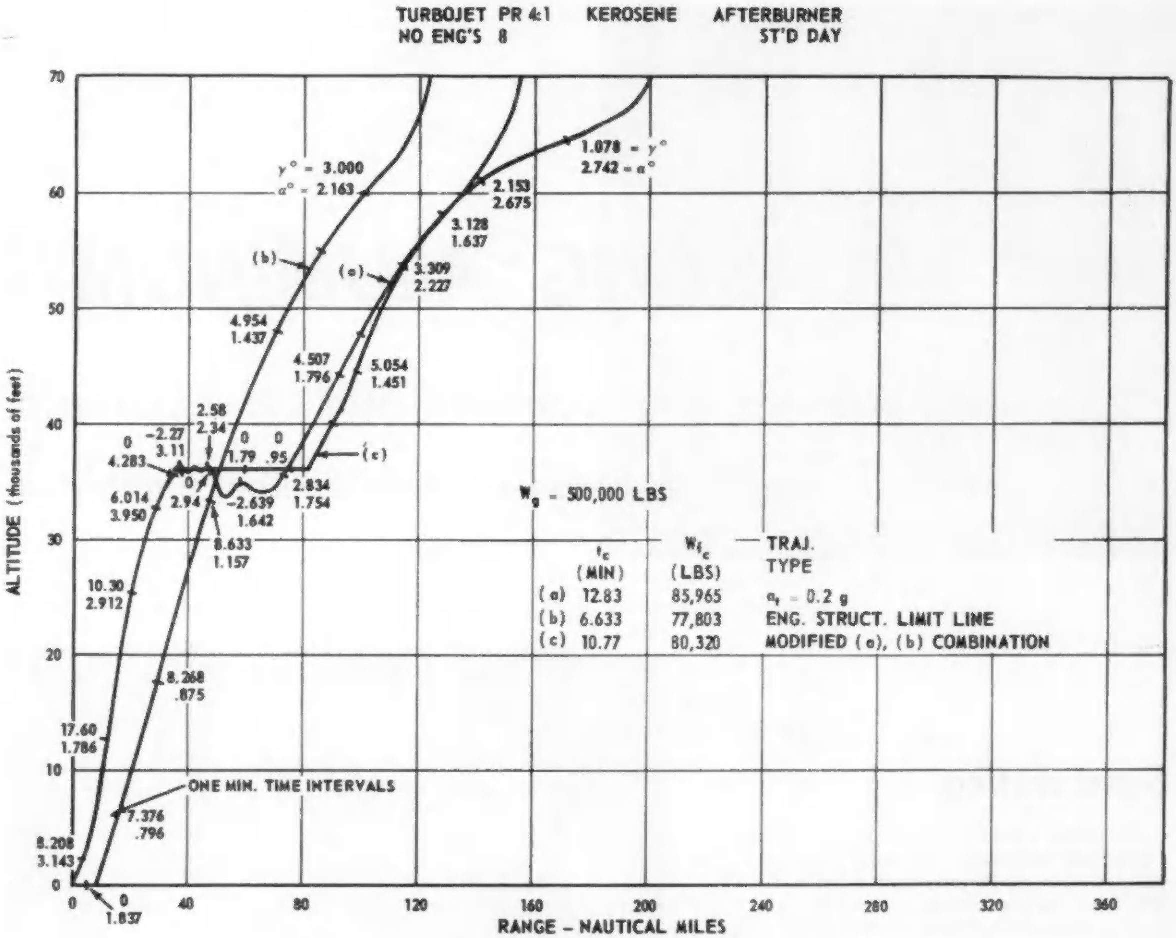


Fig. 6 — **Alternative climb** trajectories for optimized climb.

mentation will enhance the range capability somewhat, but its usefulness is limited, as already noted.

The descent from end of cruise altitude (approximately 108,000 ft), is accomplished by means of a powerless glide in order to conserve fuel. During the glide the ERJ engines are extinguished and retracted. At a nominal Mach number of 1.25, and altitude of 35,000 ft, the turbojets are ignited for a power let-down and landing.

The overall trip performance of the hypersonic transport will depend on take-off weight and fuel reserve. An optimistic value for reserve fuel is 12% of the total fuel. On this basis, for a 700,000 lb configuration, the nominal fuel reserve will be about 50,000 lb. The corresponding range and trip time are 3600 nautical miles and 89 min, respectively. This is little better than half of the original objective of 6000 nautical miles.

To further increase the range, a greater proportion of the fuel must be used for cruise. The availability of greater proportions of cruise fuel depends largely upon how much the engine efficiency can be improved, thermal and cooling requirements reduced, and the possible use of droppable tanks or of inflight refueling. For example, the climb and acceleration flight phase consumes an enormous amount of fuel. Any improvement in specific fuel consumption, however small, is important. Also, thermal insulation and cooling weight requirements are generally in excess of 15,000 lb. A reduction here would significantly increase cruise fuel.

Droppable fuel tanks would permit a large increase in fuel storage capacity for a small temporary structural weight penalty. However, their large size is detrimental drag-wise, they are costly, and their safe disposal is a problem.

Climb and acceleration to Mach 0.8 and 35,000 ft entails approximately 30,000 lb of fuel. Using inflight refueling to top the tanks at this point would add about 500 nautical miles to the cruise range. Any effort to improve the range performance is likely to be most fruitful if it is concentrated on a reduction in climb and acceleration fuel through more efficient engines, and on reduction of insulation and cooling weight.

Increasing the gross weight might also help. A 1,000,000 lb configuration with zero fuel reserve would probably allow a range of 5700 nautical miles, which refueling would bring to 6200 nautical miles.

To Order Paper No. 427C . . .
from which material for this article was drawn, see p. 6.

CASTING ALUMINUM—

Sand, semi-permanent mold, permanent mold, die casting—each certain times. Case histories illustrate recent application

Based on paper by

John Lapin

Central Foundry Div., GMC

Sand casting

No other casting method has resulted in the exceptional flexibility of sand casting. Castings of almost unlimited size and with extremely complex internal coring are being produced. The internal coring is made by placing dry sand cores (Fig. 1) in green sand molds. The molds are formed by ramming a special molding sand mixture around a wood, plastic, or metal pattern.

The process has a low initial pattern cost, low cost of making engineering changes, and samples or short production runs can be made in less time than for other processes.

The flexibility of the sand casting process can be illustrated by the casting of aluminum intake manifolds for V-8 engines.

The manifold is a complex, highly developed casting containing many passages for engine coolants and fuel mixtures (Fig. 2). The design, turnaround factor, availability of capital equipment, tooling costs, and other factors dictated the use of sand casting for this part.

A special mixture of urea formaldehyde bonded sand is used to make the two cross-over cores and the water jacket core (Fig. 3). The cores are blown in automatic core blowing machines, which operate two double cavity core boxes. One pair is drawn from the core box and placed in driers, while the other pair is being blown. The cores are baked in a vertical core oven at 410 F.

The two impression green sand molds are produced on semiautomatic, jolt-squeeze molding machines. Cores are set, and the molds are closed on a moving platform conveyor. The molds pass by a 20-ton reverberatory holding furnace where the molds are poured by hand. The molds remain closed for 15 min, after which they are opened and the castings, with the cores still inside, are removed and placed on an overhead cooling conveyor for one hour.

The core sand is removed by pneumatic vibrators which grip three of the risers. A trimming operation shears the gates. The risers are removed in a single pass fixture containing two circular saw blades. The castings are then stabilized in batch type furnaces and are 100% pressure tested for leakage between the passages or to the outside of the casting.

Pattern changes on the molding line are made in 30 min, and any combination of two different manifolds can be run.

SAE 323 aluminum alloy is used.

Semi-permanent mold

The semi-permanent mold process combines some of the flexibility of the sand casting process with some of the economies of the permanent mold method. Complex internal coring is produced by use of expendable sand cores. The outer configuration of the casting is shaped by a metal mold which may be used for 100,000 castings or more. Fig 4 shows a cross-section of a semi-permanent mold.

Aluminum V-8 engine cylinder blocks and heads are being produced by the semi-permanent mold process. The flexibility of the process permits production of blocks with cast-in iron liners combined with a closed-deck design. Other methods prove less economical when the factors previously mentioned are considered.

To produce each block casting, six sand cores are used. Four cores form the crankcase area and two form the water jackets.

The urea-sand core mixture provides the good collapsibility and low gas evolution needed in this operation.

SAE 323 aluminum alloy is used for the cylinder

Which Process?

can be used to advantage at

of all four techniques.

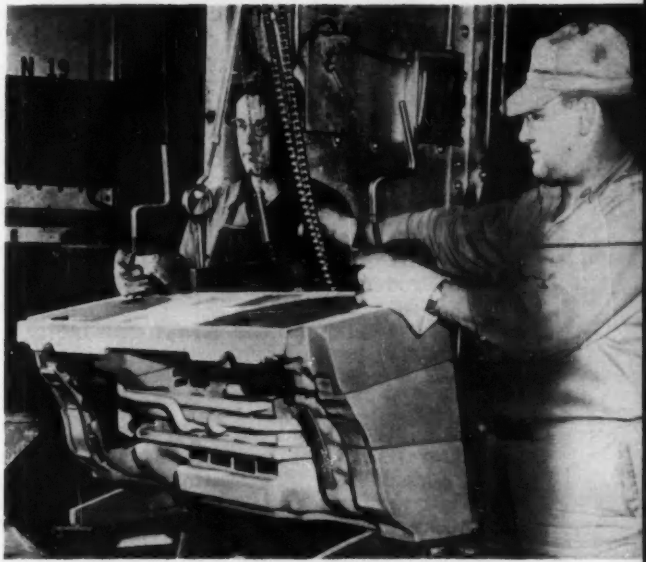


Fig. 1 — Baked dry sand core assembly for tank transmission housing.

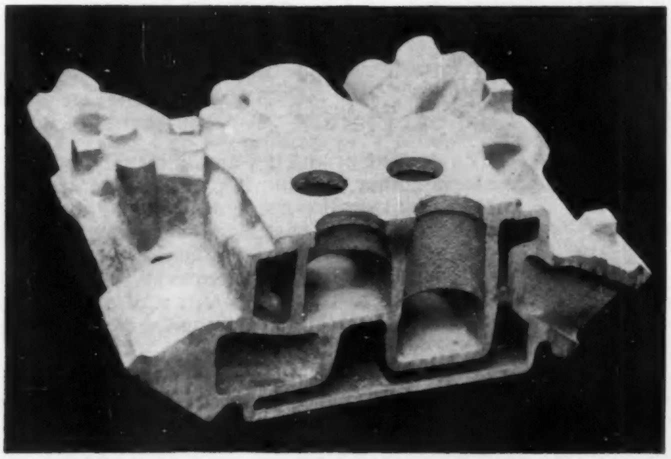


Fig. 2 — Cross-section through aluminum intake manifold for V-8 engine with 4-barrel carburetor.

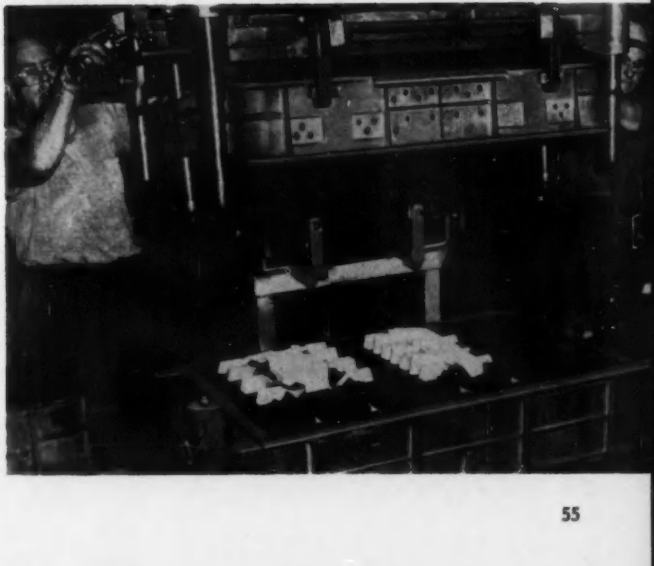


Fig. 3 — Two-impression green sand mold with dry sand cores for automotive intake manifolds.

ALUMINUM CASTING TECHNOLOGY today offers the part designer a diversity of processes, each with advantages peculiar to the particular process. To reach a proper decision on the optimum casting process for a given part, it is frequently necessary to evaluate the following process factors:

1. Part design.
2. Product performance.
3. Cost per piece.
4. Lead time and the turnaround factor.
5. Capital investment, sales, and economies.

Part design

The design of a part for aluminum should take into account the casting process by which it will be produced. The design factors which are the most important in determining process are: wall thickness, size, and internal undercuts. To produce a part by one process, when it is specifically designed for another, is often possible but only at the expense of incomplete realization of the cost savings for which the designer aimed. Such other design factors as metal content, machining stock, cast-in versus pressed-in inserts, cast-in versus machined-in undercuts or undercuts produced by the assembly of two separate castings, and others just as important to the ultimate cost of the part, need to go beyond the question, "Can it be done?"

The engineer accustomed to designing parts for iron and steel must bear in mind, when designing for aluminum, the difference in the moduli of elasticity of these materials. Further, the designer must satisfy strength, rigidity, and process requirements.

In sand casting, allowances for core shifts and finish stock must be watched. In permanent molding or die casting, these allowances can be less than in sand; but, the part must be designed without backdrafts or undercuts. The semi-permanent mold process, utilizing both iron molds and disposable cores, permits the designer to compromise between the design requirements for sand and those for permanent molding and die casting.

Comparative ratings of some of the factors which must be considered before a process is selected are shown for four casting processes in Table 1. Table 2 compares typical tolerances for aluminum casting processes.

Product performance

Having agreed on a suitable design, the performance of the part is predicted from published physical, chemical, and mechanical properties of the material. But, since design and special applications often require more than just handbook properties, it is usual to make some prototype tests. Then, pilot production runs are made to refine original estimates.

Cost per piece

The cost of producing a casting depends on material, labor, and burden. These factors are affected by the alloy specified; size, weight, and complexity of the casting; dimensional tolerances required; the type of equipment to be used; and the quantity required. Complete cost analysis of these elements and others are needed to accurately determine the best process

CASTING ALUMINUM— Which Process?

. . . continued

block and head castings. The metal is melted in 40,000 lb reverberatory furnaces which permits fluxing, cleaning, and spectrographic analysis before the metal is delivered to the casting operation. The molten metal is transported to 1700 lb gas fired holding pots at the pouring stations. Samples are taken from the holding pots and checked for gas content which is held at a controlled level to produce shrink-free, high quality castings.

The molding operation is performed with special hydraulically operated machines to which the metal mold sections are attached. Temperatures at seven critical positions of the molds are recorded and controlled effectively by water cooling passages in the molds. The permanent molds are made of SAE H-13 steel.

In preparing block molds for pouring, preheated gray iron cylinder liners, machined on both ID and OD, are placed on retractable mandrels in the mold. No metallurgical bond is needed because a lathe-turned OD thread combined with the preheated surface results in a good mechanical bond. In both the block molds and head molds, the cores are set by hand, the mold hydraulically closed, and the metal poured.

After cooling, castings are removed from the molds and vibrated to remove core sand. A special machine removes some internal fins and breaks off the gates. A shot-blast operation removes any residual sand. Both block and head castings then pass through a continuous furnace where they are stabilized by heat treatment (5 hr at 400 F).

Inspection includes pressure testing and gaging. Block castings pass through a qualifying machine which locates and mills target areas in relation to the cylinder bores. An air-electronic machine

from a foundry cost standpoint. Remember too that the customer's machining and assembly costs are often affected by the casting process selected.

Lead time and turnaround Factor

The lead time needed to build tools and supply production castings is usually a fraction of the more inclusive turnaround factor. This factor includes tooling lead time, the obsolescence cost of existing facilities, and the space and expense required in both the customer and supplier organizations for design and testing of prototypes, pilot production, training, development of procedures and devices necessary for product reliability, and reduction of production costs to forecast levels. Experience reveals that adequate lead time increases the possibility of cost savings.

Capital investment, sales, and economies

The importance of having to earn on capital investment makes it mandatory that consideration be given to the sales probability of the product, and to the economic justification for abrupt changes in technology. For example, the conversion of a cast iron part directly to a die cast aluminum part is not always the most economical thing to do; similarly, the ultimate in weight reduction is not necessarily the ultimate in economy. Compromises between the ultimate and the economically practical are often dictated by the capital investment required, the anticipated sales volume, and other economic factors.

Table 1 — Comparative Ratings of Casting Processes for Aluminum

Factor	Sand	Permanent Mold Semi	Permanent Mold Full	Die Casting
Design flexibility	1	2	3	4
Tooling cost	1	2–3	2–3	4
Capital investment	1	2	2	3
Tolerances	4	3	2	1
Turnaround factor and lead time	1	2	3	4
Metal content	4	2–3	2–3	1
Labor content	4	3	2	1
Surface finish	4	3	2	1
Assembly cost	4	3	3	1

Table 2 — Comparison of Design and Tolerance Standards — Aluminum Castings

	Sand	Permanent Mold	Die Casting
Linear tolerance — 5 in.	±.030	±.016	±.008
12 in.	±.045	±.030	±.015
18 in.	±.060	±.045	±.018
Possible parting line Separation or shift	±.045	±.030	±.015
Finish stock — 5 in.	.090	.060	.020
12 in.	.120	.090	.030
18 in.	.180	.120	.040
Wall thickness — normal minimum	.180	.160	.090
normal maximum	no limit	.600	.280
Maximum ratio of thickest to thinnest portion of casting	no limit	3.5/1	2.5/1
Desirable draft, deg	2	5	1
Minimum diameter of cored holes	.500	.250	.140

makes the final dimensional check by locating on the milled targets and checking the locating of 22 areas including each cylinder bore. Some of these operations are shown in Figs. 5–8.

Permanent mold

The permanent mold process is characterized by the use of metal molds, which can be used for producing a large number of castings with very little maintenance except for the periodic repair of the insulating mold surface coating. This coating controls chill rate, promotes directional solidification, and controls the surface finish. The cross-section of a permanent mold is shown in Fig. 9.

Two applications in which the permanent mold process is being used to advantage are the bi-metallic brake drum and the automotive piston.

A bi-metallic front wheel brake drum, consisting of a machined iron liner metallurgically bonded in

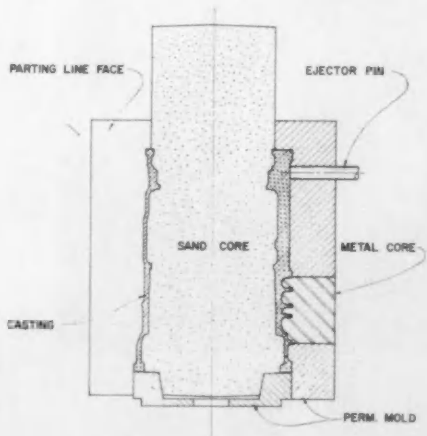


Fig. 4 — Cross section of semi-permanent mold.

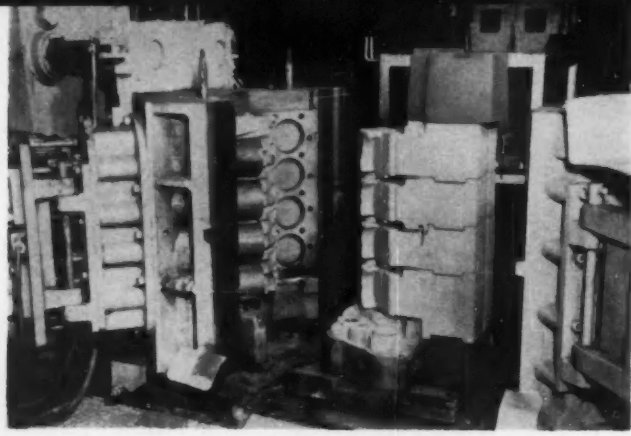


Fig. 5 — Semi-permanent mold for V-8 engine block with dry sand cores set, ready for closing.

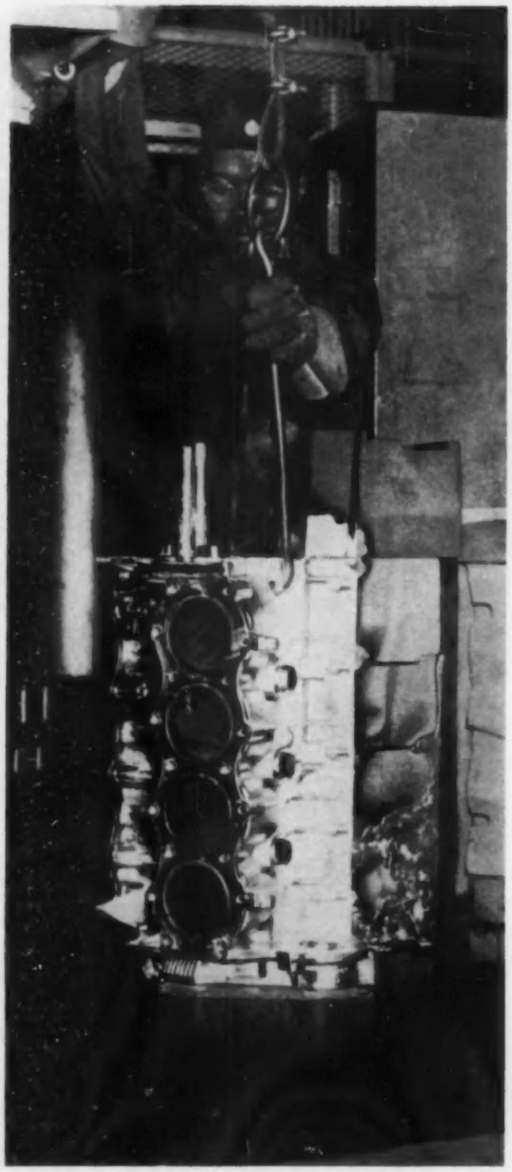


Fig. 6 — Removing V-8 engine block casting from semi-permanent mold.

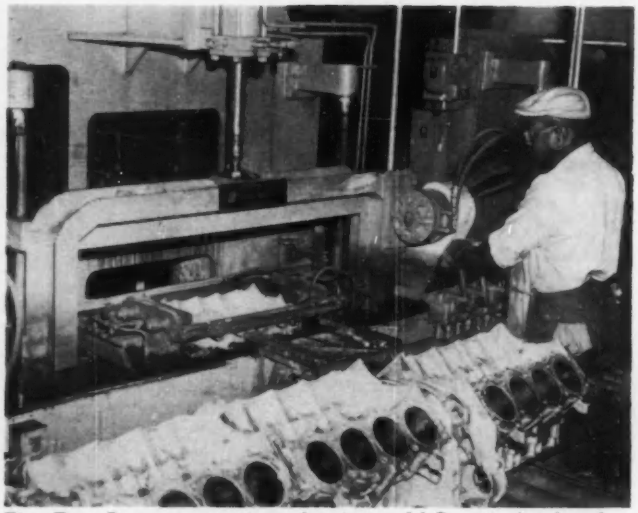


Fig. 7 — Pressure testing aluminum V-8 cylinder block castings.

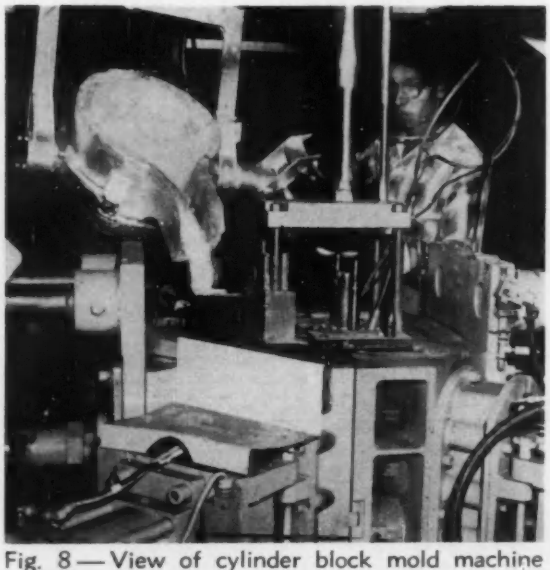


Fig. 8 — View of cylinder block mold machine with dies closed and metal being poured.

CASTING ALUMINUM—Which Process? . . . continued

a finned aluminum drum, dispels heat up to five times faster than ordinary drums, is said to practically banish brake fade, and allows the brakes to stop the vehicle faster and last longer.

Horizontal metal molds are carried on a multiple station "merry-go-round" adjacent to a bonding furnace, the metal holding furnace, and the casting conveyor. Closing and opening of the horizontal molds, and ejection of the castings are done by cam action.

Cast iron liners are first machined, and then conveyed through a bath of pure aluminum at 1300 F to form an intermetallic compound of iron-aluminum on the surface which is to be bonded to the aluminum. After removal from the conveyor, the liners are placed on the lower "drag" portion of the horizontal mold. The mold is closed, and the casting poured. Less than 30 sec is permitted between removal of the liner from the bath to filling the mold with metal to assure a true metallurgical bond (Figs. 10–11).

The casting is manually removed from the mold and placed on a tray conveyor. The mold continues to move on the merry-go-round to the liner loading station without the application of heat but with an occasional "touch up" of the mold surface with mold coating.

The castings are trimmed on a mechanical press and then rough turned on the ID. The bolting flange is drilled and faced and each brake drum is ultrasonically tested to assure a complete bond of the liner to the casting (Fig. 12). This bond assures fast removal of the heat generated by the braking action of the car.

Aluminum automotive pistons are being cast by the permanent mold process in molding machines of special design which are equipped with automatic strut setters and casting unloaders. Each machine operates two molds and one operator is required for two machines (Fig. 13).

Molds are made of SAE H-13 steel and cast iron and consist of the mold halves, a five-piece steel collapsible core assembly which forms the interior of the piston, and the bottom ring section (Fig. 14). The mold halves, center core, and wrist pin cores are water cooled. The two pistons are gated into the skirt from a common runner and are poured with the combustion side up.

The pistons are rough finished on a 14-station transfer machine which:

1. Removes gates and riser.
2. Rough machines the OD.
3. Faces and chamfers the head.
4. Faces and chamfers the skirt.
5. Weighs each piston.

The pistons are heat treated for 8 hr at 400 F in

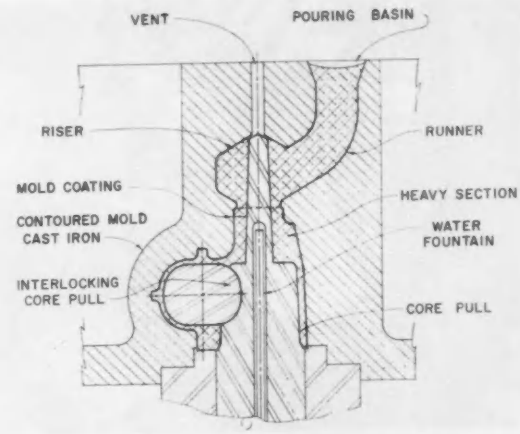


Fig. 9 — Cross section of permanent mold.

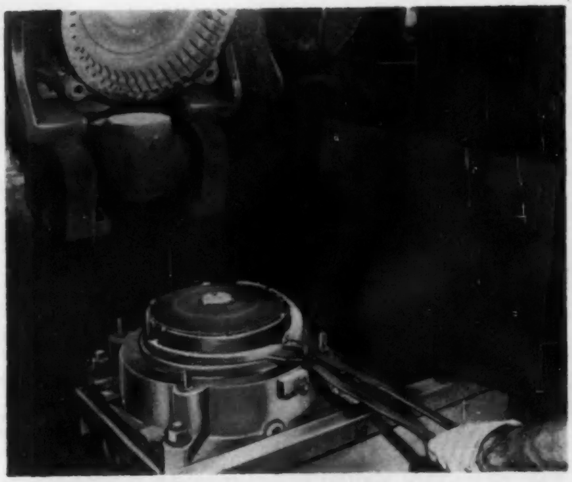


Fig. 10 — Loading a bonded cast iron brake drum liner into lower half of a permanent mold.

Fig. 11 — Pouring aluminum brake drum in permanent mold on a 10-station rotary molding machine.

Fig. 12 — Sonic testing finished brake drums to check metallic bond between cast iron liner and the aluminum.

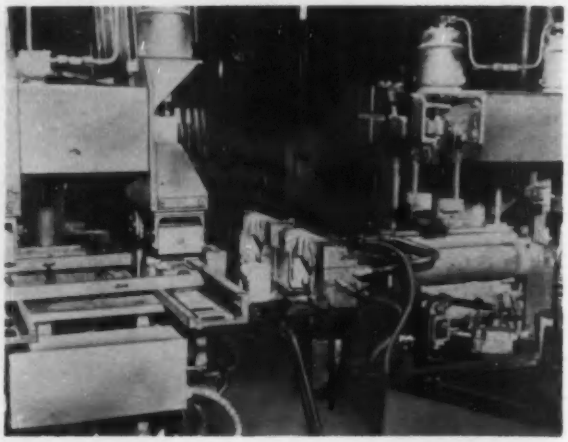


Fig. 13 — Two station piston molding machine with automatic core setter (left) and automatic unloader (right).

CASTING ALUMINUM— Which Process?

. . . continued

a continous gas-fired horizontal oven.

The success of the piston production operation is largely a matter of control. Important control points are:

1. Metal — particularly gas content, analysis, and nonmetallics.
2. Struts — weight dimensions and cleanliness.
3. Molding — cycle operation, casting defects, and dimensional gaging.
4. Weight — 100% production inspection.
5. Dimensional layout — in addition to gaging.
6. Production — metallographic examination on a quality control basis.

The highly developed piston technology, with the large volume involved, makes it essential that these controls be applied.

Die casting

Die castings are produced by injecting molten metal very rapidly into a steel die and applying a high pressure to the metal during solidification. With the largest die castings, the die cavity is filled in a fraction of a second. Casting pressures up to 12,000 psi are used. These pressures, of course require very rugged dies and machines.

The resulting castings are fine grained, with a dense skin, and a good surface finish. Dimensional tolerances are better than those obtained by other casting methods.

Design is a primary consideration in the successful production of die castings. To get minimum cost along with the soundness of die castings, the following principles are observed:

1. Uniform section thickness.
2. Simplicity of parting lines.
3. Simplicity in coring.
4. Provision for easy trimming.

Section thicknesses can vary in ratio from 1–2.5. Any variation greater than this results in less soundness in the heavy sections. When the casting is to be machined, minimum finish stock is provided.

Minimum core pulls at simple angles and with simple geometric shapes reduce tool costs and improve production rates.

While possible, parting line flash, ejector pins, and flash formed by the meeting of two cores are located on a machined surface. Where this isn't possible, shearing or punching is provided. Some typical limits and tolerances are shown in Fig. 15.

The production of automatic transmission cases from die-cast aluminum has followed a period of evolution during which they have been produced by the sand, semi-permanent mold, and permanent mold processes. Currently, cases are being made by each process as a result of decisions based upon the economics of each situation.

Die cast transmission cases vary in weight from 11–16 lbs. The larger cases are produced on machines with 1000 tons locking force. The pressure required to produce sound castings is about 10,000 psi. Dies and machines must be able to withstand the forces resulting from such pressures and still hold to prescribed tolerances. Dies are water cooled with one water line for about 25 lb of castings per hour. (Fig. 16 shows a typical die casting setup.)

The metal is melted and held in 60,000 lb reverberatory furnaces which are batch operated. After a furnace is charged to its full capacity, it is fluxed and stirred at 1400 F. The surface is skimmed and samples are taken for spectrographic and metallographic analyses. The melt is tapped into 1000 lb ladles and delivered to the casting floor holding furnaces by special tilting trucks.

Each machine is equipped with an electromagnetic, twin-chambered furnace which pumps a measured charge of molten metal to the machine.

The casting cycle takes from 45–70 sec, depending on the particular die. After the operator closes the die, the machine automatically injects the metal under pressure, opens the die after 13 sec holding time, and ejects the casting. The operator removes

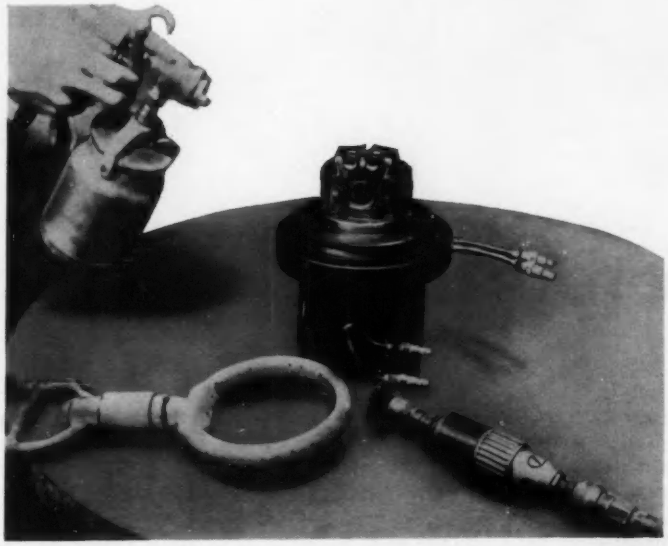


Fig. 14 — Applying mold coating to five-piece core and ring assembly for automotive piston.

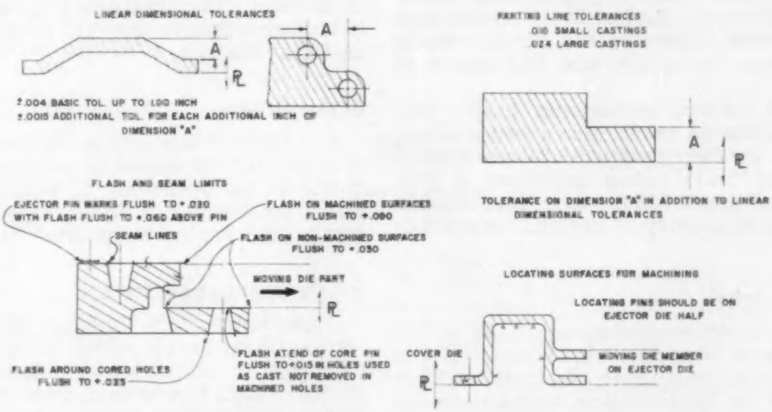


Fig. 15 — Recommended dimensional tolerances and casting cleaning limitations for die casting.

the casting and places it on an inclined roller conveyor for inspection.

Each casting is inspected within 20 min after production. Approved castings travel by conveyor to a central timming area where they are trimmed in special machines which punch, shear, and grind the flash to required tolerances.

Castings are inspected at the end of the production line by gaging, pressure testing, visual examination for casting defects, weighing, occasional sectioning, and x-ray. At least one of each type of casting per day is given a thorough dimensional check.

A final quality control inspection is made for casting defects, trimming limits, dimensions, and x-ray quality.

To Order Paper No. 389B . . .
from which material for this article was drawn, see p. 6.

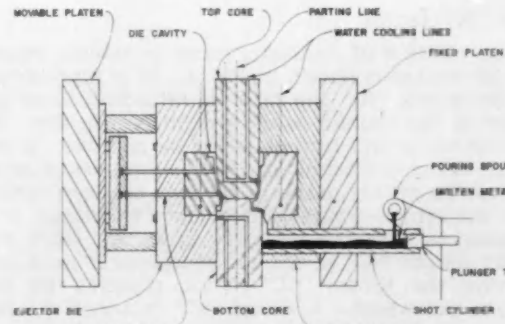


Fig. 16 — Section through a die casting machine and die.

Higher powered truck engines

Based on paper by

Stephen Johnson Jr.

Bendix-Westinghouse Automotive Air Brake Co.

TURNPIKES and limited access roads are making possible higher truck speeds, or heavier loads, or both. This in turn means higher powered engines which call for greater brake capacity and higher brake system efficiency. Brakes must absorb and dissipate the kinetic energy of the vehicle which varies directly with the weight and the square of the speed.

The important factors influencing brake performance which must be taken into account if engine horsepower is increased are: Gross vehicle weight, "K" factor, brake lining coefficient of friction, brake drums, brake application time, vehicle stopping distance, frequency of braking, and brake rating.

Gross vehicle weight

Most designers select brakes on the basis of the rated gvw, or more properly, rated load on the wheel. Loads higher than those designed for have an adverse effect on performance, particularly on stopping distance. While present limitations of weight per axle or per wheel are likely to remain for some time, proposals have been made to increase the load per wheel for vehicles on the Interstate Highway System. If this comes to pass, brake design will have to be reappraised.

The "K" factor

The relation of retarding force to vehicle weight for air brakes is shown in Fig. 1. It is represented by the factor "K," the ratio of retarding force per wheel at the ground to the weight on the tire. All the factors in this formula could be variable. If the brake lining coefficient of friction, the brake drum radius, the rolling radius of the tire, the cam radius, and the vehicle weight are all fixed by design, it is possible to vary the effective area "A," slack adjuster length "L," or the air pressure "P" and still provide the proper "K" factor required by the weight per wheel. A design "K" factor of 0.6 has been acceptable for years.

Air brake system pressures have been governed between 85–100 psi and on this basis brakes were designed to provide full braking power using 50–60 psi, thus affording excess for emergency. Pressures may be increased in the future, but regardless, the "K" factor must be adequate.

Brake lining coefficient of friction

One of the problems of brake linings has been proper identification of the many types available to insure replacement of the same type and coefficient of friction. Considerable progress has been made in this direction by the SAE Brake Subcommittee II on Brake Linings.

Brake drums

The brake drum serves as the primary heat exchanger and its design is an important influencing factor in performance. If higher powered engines affect vehicle speeds or weight or both, brake drum design and environment must be reconsidered.

Brake application time

Brake application time can be cut by proper selection of air brake system components and proper attention to tubing sizes, fittings, and methods of piping. This has been proven by laboratory tests and by oscillograph charts. Such a road test chart is shown in Fig. 2. A single vehicle does not present too great a timing problem but as trailers are added the timing becomes more difficult.

What can be done to improve application time is shown by an example, using a rig consisting of a 6-wheel tractor with 350 hp engine, tandem-axle semi-trailer, a dolly and a second-tandem axle semi-trailer. The rig had a 98-ft overall length and a gross combined weight of 130,880 lb. With the original air brake system, the stopping distance from 40 mph was 158.5 ft with 98 psi applied brake pressure. After careful study of the system and modifications of it, the stopping distance was reduced to 124 ft with the same pressure.

At present, air brake systems produce stopping distances comparable to those of electro-pneumatic systems, but if rigs are going to pull four or five trailers on the new highways, electro-pneumatic systems should be given serious consideration.

Vehicle stopping distance

Fig. 3 shows that stopping distance is composed of three parts — (a) driver reaction distance, (b)

need brakes to match

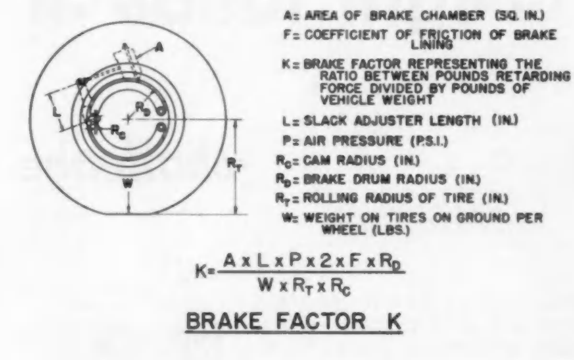


Fig. 1 — The relation of retarding force to vehicle weight for air brakes is the brake factor "K," the ratio of retarding force per wheel at the ground to the weight on the tire.

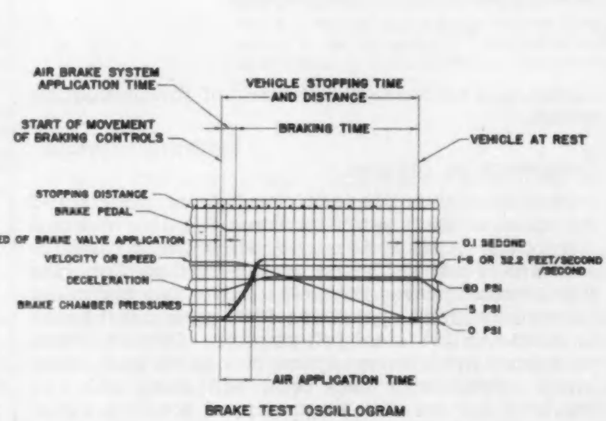


Fig. 2 — Typical oscillograph obtained from road tests to study brake application time.

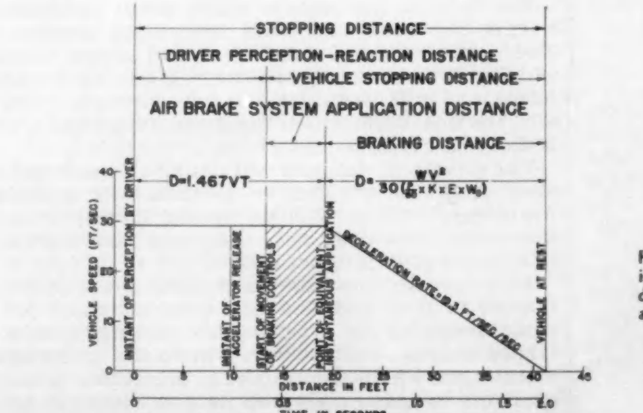


Fig. 3 — Vehicle stopping distance is determined by driver reaction distance, brake application times, and vehicle braking distance.

brake application times, and (c) vehicle braking distance. Driver reaction distance cannot be controlled; the other two can be, as shown by the formula in Fig. 4. Brake application distance is affected by vehicle speed; vehicle braking distance is affected by vehicle speed and load, brake "K" factor, and mechanical efficiency of the foundation brakes.

VEHICLE
STOPPING DISTANCE

$$S = 1.467 \times V \times T + \frac{WV^2}{30(\frac{P}{60} \times K \times E \times W_c)}$$

S = STOPPING DISTANCE (FT.)
V = VEHICLE SPEED (M.P.H.)
T = TIME FROM INSTANT OF START OF MOVEMENT OF BRAKING CONTROL TO POINT OF EQUIVALENT INSTANTANEOUS APPLICATION (SEC.)
W = ACTUAL GROSS WEIGHT OF THE VEHICLE (LBS.)
P = ACTUAL BRAKE CHAMBER PRESSURE (P.S.I.)
K = BRAKING FACTOR = $\frac{\text{RETARDING FORCE AT THE GROUND}}{\text{WEIGHT}}$
E = MECHANICAL EFFICIENCY OF THE BRAKE MECHANISM
W_c = CALCULATED GROSS WEIGHT OF THE VEHICLE ON WHICH K IS BASED

Fig. 4 — Vehicle stopping distance can be improved through control of brake application distance and vehicle braking distance, as shown by this formula.

Frequency of braking

Frequency depends upon the type of vehicle and its mode of operation. Environment also makes a difference. A study of runs made between Chicago, and New York, published by the Indiana Turnpike Commission, proves the point. Over the turnpikes the average road speed was 40.93 mph, total brake applications 194, total full stops 58. Over the state highways the average speed was 32.73 mph, total brake applications 893, total full stops 243. In trucking service the frequency of braking varies from the extremes of less than one stop or slowdown per mile to one continuous slowdown of several miles on long downhill runs.

Brake rating

It is generally agreed that any method or procedure for rating brakes to be of practical value must predict or determine brake performance. One approach is based on the ability of the service brakes to retard the vehicle safely while descending long downhill grades. After continuous downhill braking of X% grade over Y miles the brakes must be able to meet the required stopping distances. The AMA-TTMA Committee is now engaged in a study of downhill braking performance. Engine motoring power or braking power constantly used in downhill braking varies with the vehicle powerplant and is an unknown factor.

To Order Paper No. 386B . . .
from which material for this article was drawn, see p. 6.

Flight loads at

challenge

Based on paper by

Eugene O. Clay

North American Aviation, Inc.

THE PROBLEMS of prolonged flight in the earth's upper atmosphere at speeds of Mach 6 and over will test the ingenuity of aircraft structural designers. Such flights, to take place in the not-so-distant future, will subject the primary flight load carrying structure to air friction heating in the hot forging temperature range for common steels. Now the designer will have to develop air vehicles of increased structural efficiency with materials up to 3 times the weight of aluminum alloy, but less than 3 times as strong in the temperature environment in which they must work.

Fabrication a problem

Not only do the heavier alloys mean additional weight, but they also bring fabrication problems. The extremely tough new steel and nickel alloys which will be used can be produced only in limited forms, and still guarantee adequate strength. Usually, the final form which the detail design will take is dictated by these limitations.

The structural designer will not be able to remain aloof from the problem of mechanically shaping the elements which make up structural components. His design must now, more than ever take fabrication limitations into account.

As is usually the case in designing prototypes, limited funding and time schedules generally preclude designing for expensive die forgings and extruded shapes. Unfortunately, when the exotic new metal upon which the project is predicated is only available in rolled plate and narrow widths of foil, the "design of the future" must be planned around these limitations.

forging temperatures

designers

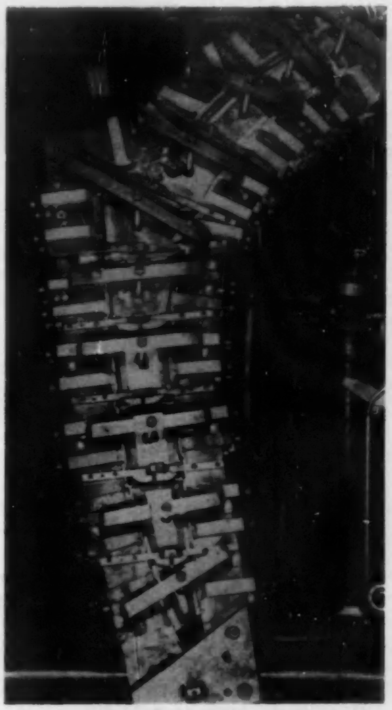


Fig. 1 — This welding and heat treating fixture proved to be a significant "state-of-the-art" development in high temperature load carrying structure fabrication.

Because of the high density of nickel-cobalt alloys, which is even greater than that of steel, the structure can easily exceed performance-dictated weight limitations. Therefore, every piece of high temperature alloy must be used to maximum efficiency. The form that is chosen must furnish the maximum strength properties which can be worked into the material.

The overall structure should be designed for a certain amount of deflection and shear buckling, but stiff honeycomb sandwich structure might be used where deflections are not advantageous. A resilient structural concept is dictated by the broad load and temperature spectrum which subjects the structure simultaneously to high load deflections and thermal expansion. Thus, in the area of maximum load reaction, shear buckling and frame misalignment should be permitted.

A good workable arrangement in such an area would be nickel alloy skin sized by shear loads, mechanically attached to lateral frames designed by shear and bending. This would allow the mass of the heavy nickel-alloy skin to be used for inner and outer frame and wing spar caps where, combined with the skin, the material will work directly. The risk of added weight for redundancies is then eliminated.

In areas which are designed by fuel, personnel and environment compartmentation, brazed honeycomb sandwich structural walls and bulkheads would normally be considered. Since high temperature nickel-alloy foils are available in thin guages for brazed honeycomb applications, it is feasible to design compartments near the neutral axis or semiremote from areas of maximum load deflection. Braze alloys are being developed which will hold panelized structures together at temperatures up to 1500 F, but they are not expected to handle large local loads in this heat range.

Current progress

Some progress in high temperature structural design has been achieved at North American Aviation during the final development of a long range, Mach 3 fighter. In this case temperatures around 1450 F emanating from approximately 240 sq ft of burner and enclosed tail pipe area impinged on structure already conducting 500–600 F from Mach 3 air friction acting on the outer skin and walls. Insulation and shielding would not have been effective because the high temperatures were sustained over too long a period.

The chosen design for the wing support structure was composed of nickel-cobalt alloy and had a limit load factor of 7.33 g while subjected to a maximum temperature of 1200 F. Under emergency conditions, with a 10-min fire heating the frame caps to 1600 F, a load factor of 2.4 g would be maintained.

This design made judicious use of small die forgings welded into the composite network to eliminate biaxial stresses in the welded joint adjacent to load concentrations and attach points. A costly series of large die forgings was thus eliminated; yet desired forms were attained. A major contribution to the job of fabricating the parts was given by a new technique of accurately holding the many small parts in place for welding. Fig. 1. shows a welding and heat treating fixture for the large nickel-alloy frame. It also helped support thin webs and stiffeners against warping.

To Order Paper No. 420D . . .
from which material for this article was drawn, see p. 6.

"DE-CEL" stops the big ones

New aircraft arresting system acts like a water brake.

Based on paper by

E. Groothuis and J. Thousand

Nortronics

DE-CEL, an arresting system for jet transport aircraft, may help curtail accidents due to landing over-runs or short landings. This system is continuously available for instantaneous all-weather use, and requires no modification to the aircraft. It has a reasonable initial cost, low maintenance cost and requirements, and long service life. It is also attractive from the reliability standpoint, which is probably most important, since mechanical, electrical or electronic actuating devices are absent. Furthermore, it is completely non-damaging to the aircraft.

DE-CEL was conceived to stem landing accidents, which have been on the rise ever since the introduction of high performance jet aircraft. The higher landing speeds and weights of the jets require longer runways than did the previous generation of propeller driven aircraft. With these new aircraft, many of the nation's runways are marginal under adverse operating conditions.

Emergency stops when conditions for take-off and landing are normal are not the problem. Rather it is the abnormal conditions, such as pilot misjudgment or misintepretation, aircraft component malfunction, marginal or changing weather conditions, and shifting ground winds that are of greatest concern. Despite the most ingenious maintenance equipment, it is not always possible to assure good runway conditions at a crucial moment.

When runways are wet or oily, or covered with ice, snow, sand, or debris, poor braking results. This is the most common condition surrounding over-run accidents. The reduced friction coefficients encountered in these situations can make a safe stop on a critical runway impossible. Wheel brakes and reverse engine thrust combined may not provide adequate deceleration under such conditions.

Past approaches

The military, which has coped with this problem for years, has employed several decelerating systems. These have worked with reasonable success, but with less than the 100% reliability demanded by the air traveling civilian public. Most commonly used is the hook and cable arresting gear; where a hook on the aircraft is caught by a cable stretched across the runway. Some form of energy absorbing device is attached to the cable. There are many variations of this theme but they all require cable engagement at all velocities and under all weather conditions. Besides they must rely on human assistance to actuate the system. This method also requires modification of the existing airframe, which adds expense and weight.

Some systems have eliminated the hooks by using the cables to engage the landing gears. Also in use are nets thrown up as a barricade to catch the en-

tire aircraft. Lives are saved by these systems, but in most cases the aircraft is damaged.

Success with the hook and cable principle can be mainly attributed to the alert state of the crew to the approaching emergencies. Besides, the military crew is usually strapped securely in place and can tolerate high rates of deceleration due to above average physical condition. Commercial passengers, on the other hand, represent a wide range of age and physical conditioning, and are not usually aware of an approaching emergency. Studies have placed the maximum deceleration rate required to prevent injury to commercial passengers at 0.8 *g*.

Water does the trick

Water is the active ingredient in the DE-CEL system. The new method is based on the principle of absorbing the kinetic energy of a rolling aircraft by continuously displacing large volumes of water. A basin filled with water and covered with a specially designed flexible mat is installed at the end of the all-weather runway. The entrance and exit ends of the basin are sloped to allow smooth transition into and out of the basin.

As the aircraft enters the basin it depresses the flexible cover, displacing large quantities of water ahead of the landing gears, as shown in Fig. 1. The increased rolling resistance decelerates the aircraft uniformly and safely, much the same as a water brake. The depth of the basin is designed to the maximum design drag load on the aircraft's landing gears, to avoid damaging the aircraft. The cover is made flexible enough to allow the wheels to sink readily into the water and to form a wave ahead of the gear; yet strong enough to withstand the tension load imposed as the aircraft rolls through the basin. The cover prevents water from enveloping the aircraft upon entry into the basin, and it increases the effectiveness of the displaced fluid by controlling and containing the wave that is formed. For maximum performance it must be rigidly attached at the basin entry and flexibly attached to the sides of the basin. After the aircraft passes, the cover returns to the original position ready to accommodate another over-run incident immediately. The water can be treated to withstand freezing, algae formation, and other environmental effects.

Tests conducted by NASA to compare the performance of the DE-CEL covered basin to an open water basin demonstrated the superiority of the DE-CEL system. These tests, with a scale model of a Boeing 707, showed that the covered basin required less stopping distance for the same water depths and entrance speeds. In addition, aircraft damage due to water impingement was eliminated. During tests conducted at a 75-knot entry into the open water basin, the displaced water tore the flaps from the model.

It was also found that a looser cover creates more drag and gives more efficient performance. There was no consistent course of deviation of the model from the centerline of the basin due to DE-CEL characteristics.

The overall test results indicated that it is possible to design a covered DE-CEL basin 600–700 ft long, sloped to a depth of about 2 ft, which will satisfactorily arrest an aircraft at entry speeds up to 75 knots. At higher entry speeds DE-CEL is less efficient because the wheels "plane," or undergo a series of shallow, sinusoidal oscillations before they settle into the basin. But, since over 90% of commercial aircraft over-runs have occurred at speeds less than 80 knots at the end of the runway, design for higher speeds is not felt to be necessary.

An operational test program has been proposed to the FAA, but must await final analysis of NASA tests.

To Order Paper No. 435C . . .
from which material for this article was drawn, see p. 6.

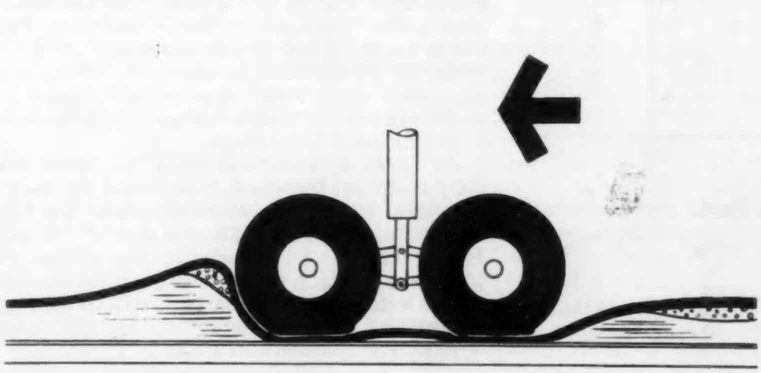


Fig. 1 — The water displaced by the landing gears increases the rolling resistance and effects the transfer of energy.

Selecting the **right**

. . . requires reflection on the duty cycle. The universal necessarily meet the needs

Based on paper by

W. T. Condon

Twin Disc Clutch Co.

Table 1 — Duty Cycle of Off-Highway Truck

Gear Ratio	Converter Speed Ratio	% Time	Engine Speed	Engine Power
Reverse	0.41	6.0	2100	400
Neutral	1:1	31.3	400	5
1st	- - -	- - -	- - -	- - -
2nd	0.39	4.2	2100	400
2nd	Lockup — 1:1	10.2	2100	400
3rd	0.71	8.3	2100	400
4th	.0.74	9.0	2100	400
5th	.0.64	6.5	2100	400
5th	Lockup — 1:1	24.5	2100	400

Engine hp — 400
Max engine speed — 2100
Converter stall torque — 2800 lb-ft
Tire rolling radius — 33.3 in.
Weight on drive axle — 80,000 lb
Overall axle ratio — 18.24:1

Transmission ratio — Reverse — 4. 64:1
1st — 4. 64:1
2nd — 2. 17:1
3rd — 1. 53:1
4th — 1. 11:1
6th — 0.784:1

Table 2 — Duty Cycles

Vehicle	Torque, T	Speed, n	% Time
Highway Vehicle	1.8	0.5	12.5
	0.9	1.0	12.5
	0.6	1.5	75.0
Industrial Machinery	1.8	0.5	100
Construction Equipment	1.8	0.5	37.5
	0.9	1.0	37.5
	0.6	1.5	25.0

SELECTING the right universal joint for any application requires that the duty cycle of the equipment be known. The highway vehicle requires a universal with high static strength and low dynamic bearing capacity. The joint for industrial or construction equipment needs high dynamic bearing capacity and less static strength.

Intelligent selection of universal joints for a particular application requires that the operating torques, angles, and speeds be specified. Maximum torque can be calculated from prime mover to ground, and conversely from ground to prime mover to determine the limiting maximum torque. But, operating torques, speeds, and angles are difficult to specify for a varying load cycle. And yet, they are absolutely necessary for calculation of universal joint life expectancy.

Table 1 illustrates a duty cycle compiled from a time study of a mining operation. It represents the type of data needed for a thorough analysis of universal joint life. The data is for an off-highway truck with a 400 hp engine governed at 2100 rpm, a single-stage rotating housing converter with lockup, and a countershaft power shift transmission.

The danger in applying universal joints on the basis of maximum torque alone and the importance of a duty cycle can be illustrated by three torque-speed-time curves of typical applications. Fig. 1 shows the curve for highway vehicles, Fig. 2 the curve for large industrial machinery, and Fig. 3 the curve for a construction machine. These conditions represent those which the universal joint propeller shaft will see and are based upon constant and identical universal joint angles.

All three applications have the same maximum torque and on this basis they could all use the same universal joint size. However, from the life aspect the same universal joint size would not be correct for all three. To determine the proper universal joint size for each application, it is necessary to construct a duty cycle for each (Table 2) and apply the cumulative damage theory:

$$\text{Life} = \frac{1}{\dfrac{N_1 N_2 N_3 \ldots N_n}{L_1 L_2 L_3 \ldots L_n}}$$

where:

L_1 = Life at condition 1
N_1 = Fraction of time at condition 1

universal joint . . .

that meets highway vehicle requirements doesn't of industrial or construction equipment.

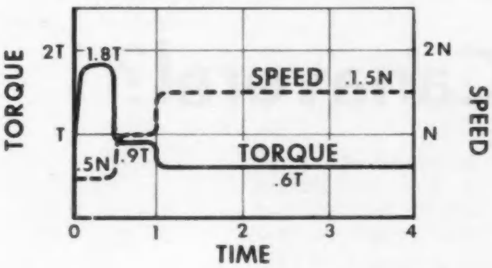


Fig. 1 — Torque-speed-time curves for highway vehicle.

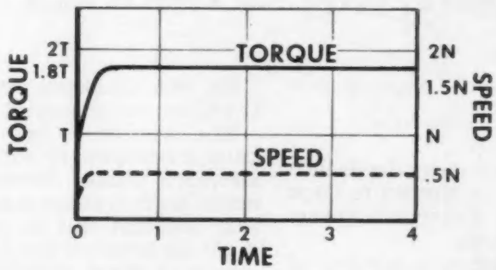


Fig. 2 — Torque-speed-time curves for industrial machinery.

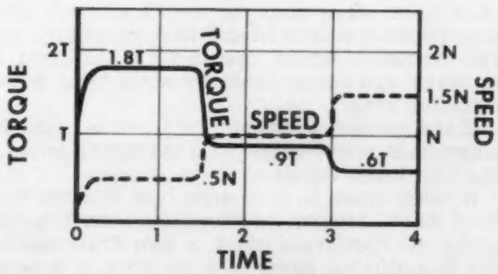


Fig. 3 — Torque-speed-time curves for construction equipment.

Assuming a dynamic factor of 1.0 for the highway vehicle universal joint the expected life will be:

$$L \propto \frac{1.43}{nT^3}$$

If the same dynamic factor of 1.0 is used for the industrial machinery and construction equipment duty cycles, the lifes are:

Industrial machinery $L \propto \frac{0.343}{nT^3}$

Construction equipment $L \propto \frac{0.620}{nT^3}$

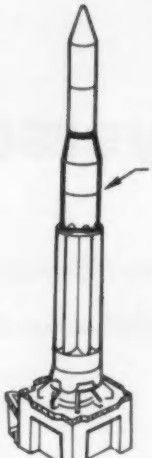
To obtain life equal to the highway vehicle, the industrial machinery and construction equipment universal joints must have the following dynamic factors:

Industrial Machinery
Dynamic factor $= 1.0 \sqrt[3]{\frac{1.43}{0.343}} = 1.61$

Construction Machinery
Dynamic factor $= 1.0 \sqrt[3]{\frac{1.43}{0.62}} = 1.51$

To Order Paper No. 403B . . .
from which material for this article was drawn, see p. 6.

Fig. 1 — **The Saturn S-IV stage** which Douglas is hoping to be able to transport by air. It is shown here as the second stage for the Saturn C-1 vehicle.



Can Saturn S-IV stage be piggy-backed by C-133 from Santa Monica to Canaveral?

Douglas is studying possibilities and is hopeful.

Would cut transport time (now by water) from weeks to hours.

Based on paper by

H. L. Lambert Douglas Aircraft Co., Inc.

RIGHT NOW, the best way to transport the Saturn S-IV stage (Fig. 1) from Santa Monica to Cape Canaveral is by water . . . . with a special highway transporter for use at terminal areas.

But Douglas is currently studying a method of hauling it piggy-back by C-133 aircraft (Fig. 2). Aerodynamic studies make the concept look feasible. The airplane would operate off standard-length runways and make coast-to-coast trips without a refueling stop.

If the method works out, total transit time by this piggy-back route would be a matter of hours. Now the trip takes weeks.

It takes three to four days just to move the S-IV from Santa Monica to Sacramento by towing . . . . along the California coast to San Francisco and up the Sacramento River to a docksite just below the city of Sacramento. None of the other ordinary modes of transport are feasible. S-IV's size makes long-distance moving over the nation's roads impractical. It would bump into all kinds of size and weight restrictions and moving-time limitations. Railroads can't be used because rail routes are designed to a width limit considerably less than the dimensions of the S-IV.

And so far, transport by air hasn't been feasible. The S-IV won't fit in the compartment of any existing aircraft. Its weight precludes use of existing helicopters. And use of lighter-than-air cargo craft is still in the "intriguing future."

So, the promising potentials of piggy-back by C-133 are being studied carefully.

The plan is to provide steel streamlined tube truss assemblies to support the vehicle above the aircraft's wings. Vertical members will carry the major portion of the loads into the wing spars. Lateral restraint will be provided by diagonal struts. A fitting between the aircraft and the S-IV's support ring offers longitudinal restraint. The truss assemblies will incorporate cradles to mate with the roll rings on the S-IV.

To compensate for some loss in directional stability, vertical stabilizers will have to be added at the tips of the existing horizontal stabilizer of the C-133. Aerodynamic fairings are installed at both ends of the stage.

The S-IV would be towed to the aircraft and positioned aft of the wing and parallel to the fuselage. A mobile crane using suitable slings would transfer the stage to the aircraft (Fig. 3). The roll rings on the stage fit into the cradles and are bolted in place. (If needed for use when the stage reaches its destination, the transporter can be disassembled and loaded into the aircraft.)

Operationally, transportation by aircraft is ideally suited to the S-IV stage since landing strips are in the vicinity of terminal points. Then, too, transportation by air would bring:

- Substantial savings in time.
- Reduction in time of exposure to corrosive and hazardous conditions.

Fig. 2 — **Piggy-back by C-133** aircraft is the method being studied for transporting Saturn S-IV by air.

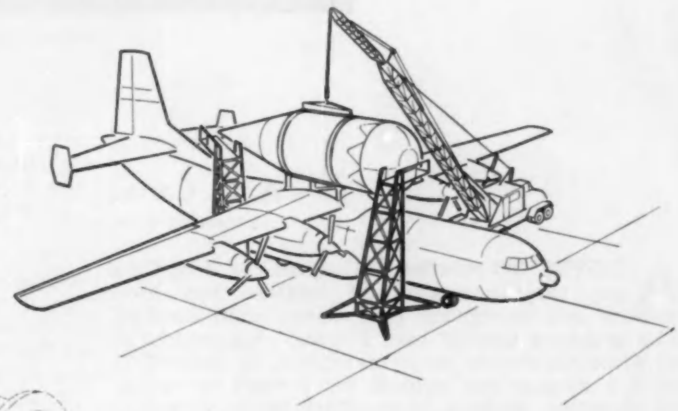


Fig. 3 — **In the method studied,** the S-IV is positioned aft of the wing and parallel to the fuselage.

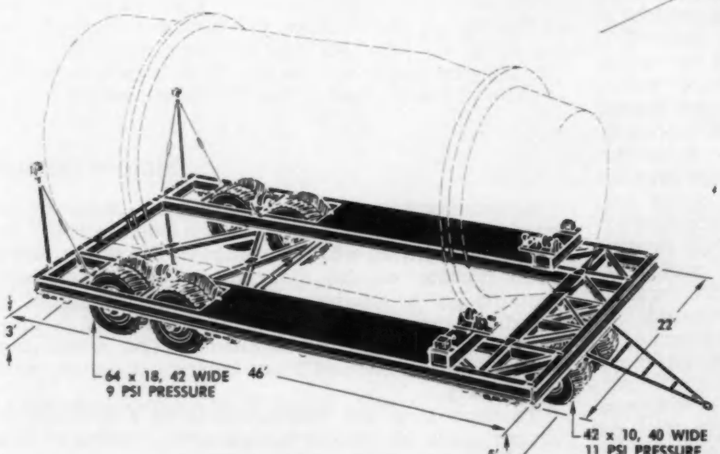


Fig. 4 — **The S-IV stage** is always conveyed on its own transporter, whether being transported by water, ground, or air. The transporter is a towable vehicle, capable of 10 mph when loaded and hauled by an M-52 tow vehicle.

- Elimination of many complexities of surface movement such as permits, escorts, moving telephone and power lines, and so forth.

Whatever the mode of transport, the S-IV is always conveyed on its own transporter (Fig. 4). This is a towable, fifth-wheel type vehicle. It is about 46 ft long without a towbar, 22 ft wide, and from 3 to 5 ft high. With the S-IV aboard, the transporter can move about 10 mph on paved roads — using an M-52 tow vehicle. It weighs about 15,000 lb, and uses expanded I-beams for major structural members. Otherwise, it is built of standard steel shapes. It may be disassembled into three major components and several small pieces for ease of shipment by truck, rail, or airplane. Bolted construction allows disassembly into two side sections, each including two wheels, and a forward section incorporating the forward wheels.

To Order Paper No. 433B . . .
from which material for this article was drawn, see p. 6.

Closed loop control

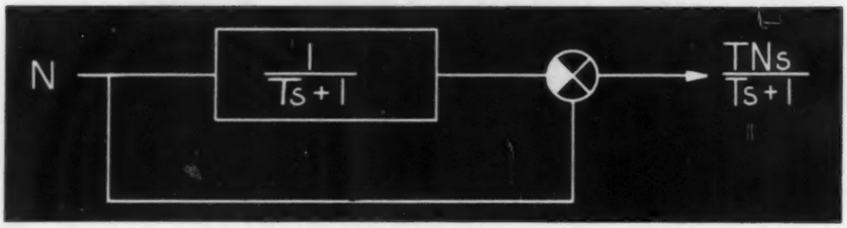


Fig. 1 — **Block diagram of acceleration sensor.**

Based on paper by

A. N. Carras

AiResearch Mfg. Co.

A DIFFERENT solution to the problem of limiting gas turbine engine acceleration has been worked out to replace the conventional method. The proposed method uses a closed loop control of acceleration during speed transients, in connection with a normal fuel control for normal operation. Acceleration limiting is required to avoid engine surge and excess turbine inlet temperatures during transients. The usual scheme is to limit acceleration by scheduling which, by definition, is subject to corrections which mean complexity and expense.

The closed loop acceleration control is not only a simpler system, but it also takes into account external changes in the system such as fuel heating value. The system operates by sensing engine acceleration — comparing it to a desired acceleration limit — then manipulating the fuel flow accordingly to prevent the prescribed limit from being exceeded.

Since acceleration is independent of ambient temperature, the need for ambient temperature correction is eliminated, subject only to the temperature correction to engine speed which can be ignored except for very marginal cases. Corrections for fuel heating value, density or temperature, are not required because of the automatic compensation of the closed loop control. The necessity for recuperator or regenerator corrective measures is also eliminated.

The object of the acceleration sensor is to give an output signal which closely corresponds to some function of the mathematical derivative of the input. This signal could be derived electrically, but hydro-mechanical means, the same as used by the main body of the control, are used by the computer.

The block diagram of Fig. 1 shows one way in which the acceleration sensor may function. On the left, a signal proportional to engine speed is introduced into a lag element. Subtracting the output of the lag element from its input leads to the following:

$$N - \frac{N}{Ts+1} = Ts\left(\frac{N}{Ts+1}\right) \qquad (1)$$

where N is engine speed; s, the differential operator; and T is the time constant of the lag element.

The output signal obtained is the first derivative of the lagged input times the time constant of the lag element. The smaller the time constant T of the lag, the closer will be the resemblance between $sN/(Ts+1)$ and sN, the true derivative signal.

Simple sensor

An acceleration sensor which uses a capillary to introduce the lag element is shown schematically in Fig. 2. The input, which appears in the upper right hand portion of the diagram, is a displacement proportional to engine speed. The output signal is the displacement of the link labeled Y, and is proportional to engine acceleration. The remaining mechanism consists of links, springs, a piston, and a capillary.

To show that the displacement of Y actually is proportional to engine acceleration, consider the force balance on the moving piston:

$$(P_1 - P_2)A_p(X - Z)K_1 = ZK_2 \qquad (2)$$

where P_1 and P_2 are the pressures on the upper and lower side of the piston, respectively; A_p is the effective area of the piston; K_1 is the speeder spring rate, and K_2 the piston spring rate. The positive sense of the displacements X, Y and Z is indicated by the arrows.

The piston velocity enters the picture by considering the flow through the restrictions, as follows:

$$A_p(Zs) = -R(P_1 - P_2) \qquad (3)$$

where R is the capillary constant.

Combining equations 2 and 3 and assuming each

. . . limits gas turbine acceleration and offers to replace the technique of acceleration scheduling.

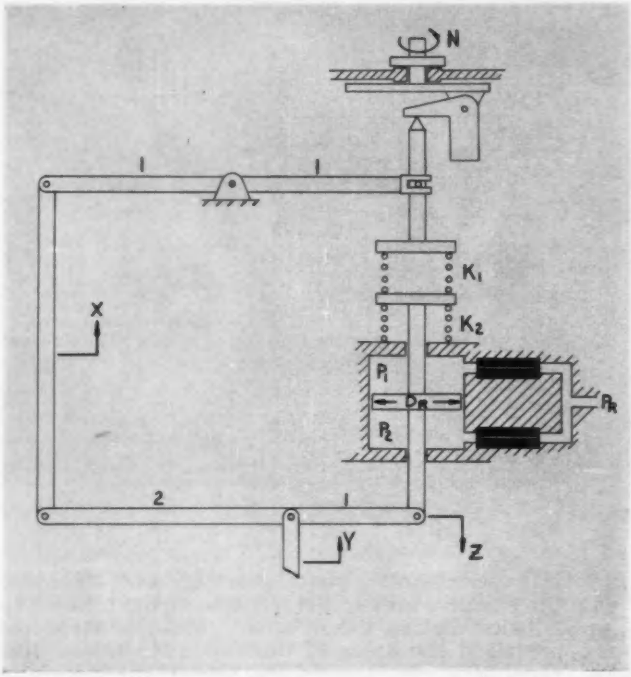


Fig. 2 — **Acceleration sensor schematic,** using capillary for flow restriction. Orifices may replace the capillary to eliminate the effect of fuel temperature change.

of K_1 and K_2 equal to K gives:

$$Z = (X/2) - T_L(Zs) \qquad (4)$$

where T_L is equivalent to $A_p{}^2/2RK$.

The linkage ratios of the diagram give the relationship between the various displacements:

$$3Y = -(2Z - X) \qquad (5)$$

Combining equations 3 and 4 gives:

$$3Y = 2T_LZs \qquad (6)$$

indicating that the displacement Y, the sensor output signal, is proportional to a constant value times the first derivative with respect to time of the difference of piston stroke and input signal stroke.

Equation 4 can be written in the form:

$$\frac{(X/2)}{(T_Ls+1)} = Z$$

which shows that the piston stroke, Z, is proportional to a lagged factor of X, the input signal. Therefore, the mechanical model fulfills equation 1 and Fig. 1.

It has already been noted that a smaller lag gives a better approximation, but as equation 6 indicates, output displacement is correspondingly lower. To maintain reasonable manufacturing tolerances, then, a compromise must be made.

An inherent disadvantage of the system is that the capillary constant, R, is inversely proportional to the kinematic viscosity of the hydraulic fluid used. If this fluid is engine fuel, large variations are possible with changes in fuel temperature.

The system can be refined to minimize the effects of fuel temperature variations by replacing the capillary by two thin plate orifices. If the geometry is chosen such that turbulent flow prevails through the orifice, the flow coefficient will be relatively constant. The density of the fluid will vary much less with fuel temperature change than the capillary constant R.

Fuel control operation

Fig. 3 shows a schematic of one possible closed loop acceleration limiting control which utilizes the acceleration sensor just described. It is the control's function to apportion the output of the fuel pump, W_p, between the engine fuel nozzles and the bypass, which returns the fuel to the pump. In this

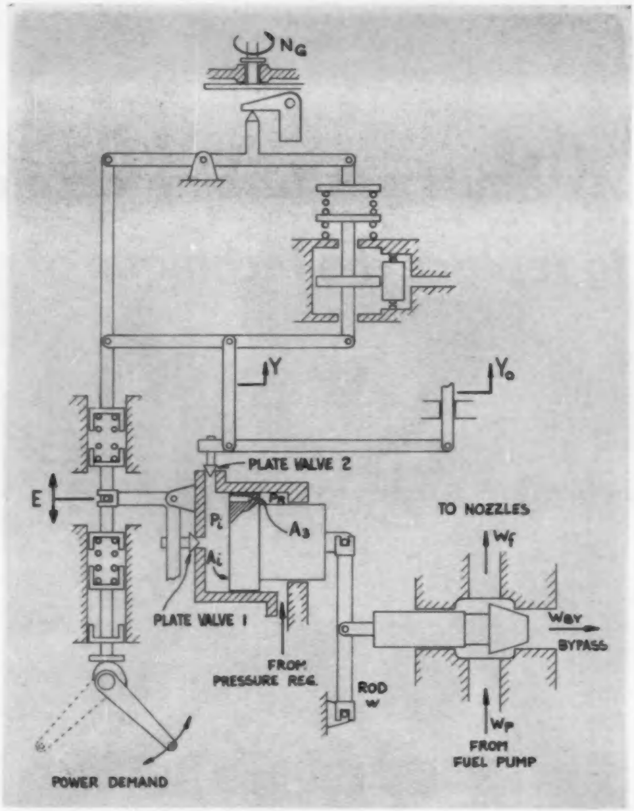


Fig. 3 — **Schematic of fuel control** which employs the acceleration sensor.

Closed loop control

. . . continued

control the bypass valve must be displaced toward the right to increase fuel flow to the nozzles.

The information available to the control is the position of the power demand lever — which specifies the desired power level, and the gas generator speed — which indicates the extent to which this demand is being met. In the case of a split shaft turbine, a free turbine speed signal would be used as an overspeed shutoff.

The cam attached to the power lever acts on the lower spring of the double spring system. The upper spring is acted on by the speed sensor. The force balance thus created positions the point E either away from or toward its steady state position. (Under any steady state condition, point E always assumes the same vertical position.) When E moves away from its steady state position, the right angle link is displaced and, in turn, changes the effective flow area of plate valve 1. This valve acts together with plate valve 2 to position the integrator piston. The stroke of plate valve 2 is the difference of Y, the displacement proportional to acceleration output, and Y_o, a displacement proportional to acceleration limiting. Plate valve 2 is closed at steady state since Y, the measured acceleration, is zero, while the limit Y_o is finite.

If the integrator piston geometry were such that the effective area of the left side of the piston (A_1) is twice that on the right side, steady state would prevail if the areas of the two plate valves were equal to A_3, the area of the hole in the integrator piston. Pressure P_i would then be equal to one half of the regulated pressure because of the area ratio.

Suppose that a positive transient takes place. At the lower power steady state point, plate valve 2, actuated by acceleration, is closed, and plate valve 1 is open, keeping the engine on speed. As more power, corresponding to higher speed, is requested by a change in the power lever position, the error between desired and actual speed closes valve 1. The buildup of P_i moves the integrator piston to the right. This pushes the bypass valve to the right to admit more fuel to the engine. When actual acceleration approaches limiting acceleration, plate valve 2 opens and controls acceleration until the new desired speed is reached. When the speed error approaches zero, plate valve 1 opens, reducing acceleration, and plate valve 2 in trying to increase acceleration saturates in a closed position. The only time that both valves are open concurrently is at the end of a transient.

The limiting demand may be varied by any engine variable or ambient condition. Gas generator speed is most convenient because of signal availability.

To Order Paper No. 398B . . .
from which material for this article was drawn, see p. 6.

Duplex truck tire—

a single to replace duals

Based on paper by

R. P. Powers

The Firestone Tire & Rubber Co.

THE DUPLEX tire, which is designed to run as a single, used as an oversize, or replace dual tires on truck wheels, is constructed with an unusually wide profile. Its section height/section ratio is 63% in contrast to 95–100% for conventional tires (Fig. 1).

Fig. 2 shows an 18–19.5 Duplex tire superimposed on 10.00–20 duals. With the Duplex moved outward to maintain the same overall tread width, the additional inside space of 5 in. on each side exposes the brake drums for better cooling. If vehicles were designed to make use of this design of tire, the springs could be set further apart to give better vehicle stability and handling.

The new tire is an outgrowth of experiments to see if a tire must necessarily be as high as it is wide in order to have sufficient flex life to withstand the millions of cycles to which it is subjected on normal trucking service. Stress measurements were taken of individual cords in a tire of this type and it was found, among other things, that cord compression was less with lower section height during rotation under load than with a conventionally-shaped tire.

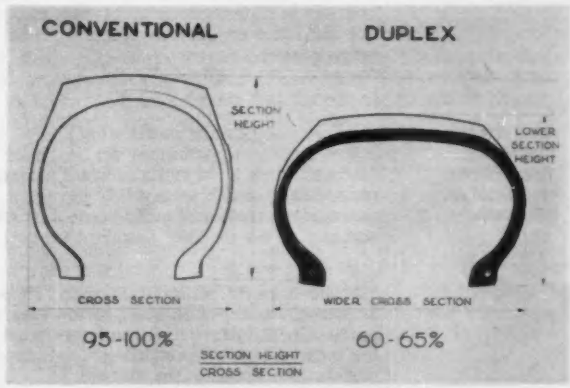


Fig. 1 — New Duplex truck tire differs from the conventional in having an oval profile which gives a wider cross section and lower section height. The periphery remains unchanged.

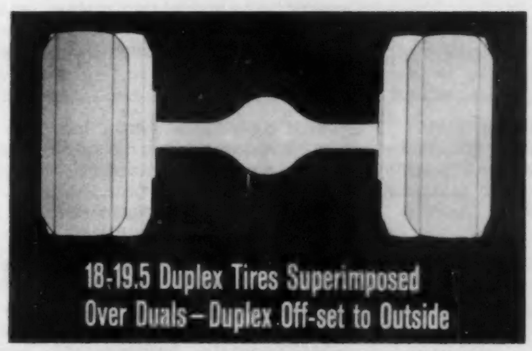


Fig. 2 — Superimposing 18–19.5 Duplex tires over 10.00–20 duals and offsetting them to the outside shows how brake drums are freed from obstruction for better cooling.

Service tells advantages

Tests of the Duplex tire on over-the-highway, bulk haulers, and off-highway units hauling gravel and cement have shown the new design to have many advantages, some of which were not anticipated. Among the more important are:

- **Easier ride.** The 10.00–20 duals have a spring rate of 10,700 lb/in. of deflection compared with 6600 for the Duplex.
- **Saving of weight.** A tire and wheel assembly can save as much as 176 to 304 lb per axle over duals.
- **Better cooling of brake drums.**

Since the Duplex tire has essentially the same diameter as the duals it would replace, it could be used in front positions of properly designed trucks. This would permit higher front axle loads without going to large diameter singles or using excessively high air pressure in standard sizes.

To Order Paper No. 415A . . .
from which material for this article was drawn, see p. 6.

Commonly used lubricant additives

Based on paper by

Peter Kalil
Texaco, Inc.

Type Additive	Type of Compounds Used	Reasons for Use	Mechanism of Action
Anti-oxidants or Oxidation Inhibitors	Organic compounds containing sulfur, phosphorus or nitrogen such as organic amines, sulfides, hydroxy sulfides, phenols. Metals like tin, zinc or barium often incorporated.	To prevent varnish and sludge formation on metal parts. to prevent corrosion of alloy bearings.	Decreases amount of oxygen taken up by the oil thereby reducing formation of acidic bodies. Terminates oil oxidation reactions by formation of inactive soluble compounds or by taking up oxygen. Additive may be oxidized in preference to oil.
Anti-corrosives Corrosion Preventives or Catalyst "Poisons"	Organic compounds containing active sulfur, phosphorus or nitrogen such as organic sulfides, phosphites, metal salts of thiophosphoric acid, and sulfurized waxes.	To prevent failure of alloy bearings by corrosive action. To prevent corrosive attack on other metal surfaces.	Inhibits oxidation so that no acidic bodies are formed or enables a protective film to form on bearings or other metal surfaces. Chemical film formation on metal surfaces decreases catalytic oxidation of the oil.
Detergents	Metallo-organic compounds such as phosphates, phenolates, sulfonates, alcoholates. High molecular weight soaps containing metals like magnesium, barium, calcium, tin.	To keep metal surfaces clean and prevent deposit formation of all types.	By chemical reaction or oxidation direction, oil soluble oxidation products are prevented from becoming insoluble and depositing on various engine parts.
Dispersants	Metallo-organic compounds such as naphthenates and sulfonates. Organic salts containing metals, like calcium, cobalt and strontium. Non-metal polymeric dispersant molecules.	To keep potential sludge forming insolubles in suspension to prevent their depositing on metal parts.	Agglomeration and deposition of fuel soot and insoluble oil decomposition products is prevented by breakdown into finely divided state. In colloidal form contaminating particles remain suspended in oil.
Oiliness, Film Strength, Extreme Pressure (E.P.) and Anti-Wear Agents	Organic compounds containing chlorine, phosphorus and sulfur such as chlorinated waxes, organic phosphates and phosphites such as tricresyl phosphate and zinc dithiophosphate, and lead soaps such as lead naphthenate.	To reduce friction prevent galling, scoring and seizure. To reduce wear.	By chemical reaction film is formed on metal contacting surfaces which has lower shear strength than base metal thereby reducing friction and preventing welding and seizure of contacting surfaces when oil film is ruptured.
Rust Preventives	Sulfonates, amines, fatty oils and certain fatty acids, oxidized wax acids, phosphates, halogenated derivatives of certain fatty acids.	To prevent rust of metal parts during shutdown periods, storage or shipment of new or overhauled equipment.	Preferential adsorption of polar type surface active materials on metal surface. This film repels attack of water. Neutralizing corrosive acids.
Metal Deactivators	Complex organic nitrogen and sulfur containing compounds such as certain complex amines and sulfides. Some soaps.	Passify, prevent or counteract catalytic effect of metals on oxidation.	Form inactive protective film by physical or chemical adsorption or absorption. Form catalytically inactive complex with soluble or insoluble metal ions.

To Order Paper No. 397B from which material for this article was drawn, see p. 6.

THE CHANGING REQUIREMENTS that have accompanied many developments in engines and other mechanical equipment over the years have been met by corresponding developments in lubricants.

Many of the improvements to meet these requirements have been made possible through the extensive use of various chemical addition agents.

The following table summarizes pertinent information on some of the more commonly used lubricant additives.

Type Additive	Type of Compounds Used	Reasons for Use	Mechanism of Action
Stringiness and Tackiness Agents	Certain high molecular weight polymers and aluminum soaps of unsaturated fatty acids.	Increases adhesiveness of lubricant on metal surfaces, form protective coating.	Increases viscosity of lubricant and imparts adhesive and tackiness characteristics.
Water Repellents	Organosilicon and other polymers, certain higher aliphatic amines and hydroxy fatty acids.	Provide water repellent or resistant properties to non-soap thickened greases and other lubricants.	Surface active agents form protective film on grease thickeners or other components of lubricants to reduce their affinity for water.
Emulsifiers	Certain soaps of fats and fatty acids, sulfonic acids or naphthenic acids.	Used to emulsify soluble oils with water to give coolant lubricant type fluid.	Surface active chemical agents reduce interfacial tensions so oil can be finely dispersed in water.
Dyes	Oil soluble organic compounds with high coloring power.	Provide distinctive or attractive color.	The organic compounds with high coloring power (dyes) dissolve to impart color.
Color Stabilizers	Certain hydroquinones, dithiocarbamates, aliphatic amines, dicyclohexylamines.	Stabilize color and prevent formation of undesirable color.	Certain chemicals can destroy color forming bodies by stopping or changing chemical reaction forming them. Sometimes accomplished by oxidation inhibitors functioning as indicated above.
Odor Control Agents	Certain oil soluble synthetic perfumes, sometimes nitro benzol.	Used to provide distinctive or pleasant odor or mask undesirable odors.	Small amounts of highly odoriferous substances impart fragrant or pleasant odor when mixed with lubricants.
Antiseptics (Bactericide or Disinfectant)	Certain alcohols, aldehydes, phenols, mercuric compounds and chlorine containing compounds.	Used to control odor, foaming, metal staining, emulsion breaking in emulsion type lubricants.	Used in soluble oils to reduce or prevent growth of bacteria causing deleterious effects in emulsion lubricants.
Pour Point	Wax alkylated naphthalene or phenol and their polymers. Methacrylate polymers.	To lower pour point of lubricating oils.	Wax crystals in oils coated to prevent growth and oil absorption at reduced temperatures.
Viscosity Index	Polymerized olefins or iso-olefins. Butylene polymers, methacrylic acid ester polymers, alkylated styrene polymers.	To lower rate of change of viscosity with temperature.	Improvers are less affected by temperature change than oil. They raise viscosity at 200° F more in proportion than at 100° F due to their change in solubilities.
Foam Inhibitors	Silicone polymers.	To prevent formation of stable foam.	Reduces interfacial tension so small air bubbles can combine to form larger bubbles that separate faster.

Foreign Manufacturing Stresses Low-Cost Materials

Based on report by panel secretary

V. G. MELLQUIST

General Dynamics/Astronautics

MANUFACTURING TECHNOLOGY in the U. S. is far ahead of foreign countries — based on first-hand accounts from continental Europe and the Scandinavian countries. Progress is being made in these countries, but at a slower rate and in a different direction due to the influence of national economies and resources.

The European countries, with their more restricted economies, are limited in the amount and therefore in the nature of research upon which technological advancement depends. So, stress has been placed on lower cost materials and manufacturing methods utilizing and refining existing technology, as opposed to developing new materials and new methods as in the U. S.

Widespread use of sandwich structures is one example of the European effort to develop manufacturing techniques for existing materials to reduce costs. Paper, impregnated with plastic and bonded to fiberglass or aluminum faces, is being used extensively in airplanes, gliders, helicopters, trucks, buses, buildings, furniture, and boats. Such composites are being produced at as little as 1/10 the cost of other materials.

A unique development in European mill rolling practice is also associated with sandwich materials. Ingot and plate, with specially built-in planes of separation, are rolled and expanded into integral sandwich configurations without auxiliary welding, bonding, or mechanical fastening methods.

An effort is being made by a group of European countries, through a joint 5-year program, to overcome the economic restraints imposed on technological advancement. This they hope will result in accelerated development of new product and material concepts, as well as new manufacturing techniques.

Most manufacturing techniques in the USSR are behind those of the U. S., but the gap may be closing. Many experts feel, however, that the Soviet disregard for human resources and material costs coupled with a zealous desire to stick with something already working, may well retard entry into more advanced follow-on programs and thus drop them further behind over the long-term future.

(Based on report of discussion at panel on Foreign Manufacturing Techniques — E. W. Feddersen, General Dynamics/Convair, chairman; Bryan R. Noton, Technical Assistant to the Director of the Aeronautical Research of Sweden and Consulting Engineer; Dr. Richard C. Potter, Space Technology Labs.)

Future Automotive Paints to Contain Today's Plus Factors

Based on report by

R. L. PITMAN

Rinshed-Mason Co.

DEVELOPMENT of automotive lacquers for the future will likely incorporate the plus features of present lacquers and enamels which through experience have proven durable, usable, materials.

Reduction in the amount and cost of thinner required would be a worthwhile contribution. Generally these characteristics are somewhat opposed to the achievement of increased film toughness and integrity, but, progress must be made in this area.

Improvement in spot repair characteristics of all colors is another worthwhile goal which is nearing solution, at least on colors as we know them today. Optimism on this development should be tempered somewhat, however, since it is difficult to predict precisely what sort of colors we will have in the future.

Arriving at a good unpolished gloss appropriate to the smoothness of the metal substrate, modified with undercoat, certainly is a realistic improvement to be expected of automotive lacquers in the reasonably near future.

It is important to retain, and strive to improve on, the color and gloss retention of the present acrylics.

All automotive finishes present opportunities for improvement in resistance to abrasion and chipping. Making major gains in this area, may, particularly in connection with chip resistance, mean revision of present thinking as it concerns other properties of the finishing system.

Pressure Vessels Need New Weld and Heat-Treat Methods

Based on report by panel secretary

W. W. HANSON

North American Aviation, Rocketdyne Division

THE MATERIALS, sizes, and complexity of present and future pressure vessels calls for a new evaluation of manufacturing techniques. Welding and heat-treat techniques must advance to keep pace with the accelerated advance of manufacturing.

Welding fixtures are already entering the field of the most exacting machine tools where they are required to control the clamping and chilling of very light-gage austenitic stainless steels. As space vehicles grow in size, the cases must become lighter. Stainless steel, 0.002 in. thick, is already being proposed for vehicles up to 50 ft in diameter. Future requirements will mean even closer controls and precision equipment capable of welding high-temperature alloys 0.001–0.002 in. thick.

Welding power supplies are available in single, wide-range control for these operations, but the fixturing is unique for each application and challenges tooling and welding engineers to give birth to their creative ideas and demonstrate methods for controlling the problem areas.

Heat treating, too, is a serious problem facing industry, but the real problem of manufacturing is machining operations subsequent to tempering. Special tools are usually required for finishing surfaces, drilling and tapping holes, and such. This is always a slow operation.

"Selective" tempering methods have been developed to reduce hardness in the areas needing subsequent operations, providing extreme hardness is not a necessity. The tooling consists of electric heating fixtures that enclose the area to be machined. The heating fixtures are externally controlled by means of a transformer.

The part is placed in the furnace and the transformer is energized. The desired area is heated 100–200 F above the rest of the part, resulting in a gradation of hardness. This simplifies the final machining operations.

(Based on report of discussion at panel on Metallic Pressure Vessel Manufacturing Techniques — C. F. Kennedy, North American Aviation, Rocketdyne Division, chairman; Larry Granstedt, General Dynamics/Astronautics; C. B. Smith, Douglas Aircraft Co. Inc.; J. W. Welty, Solar Aircraft Co.; F. H. Mathews, Boeing Aero-Space Div.)

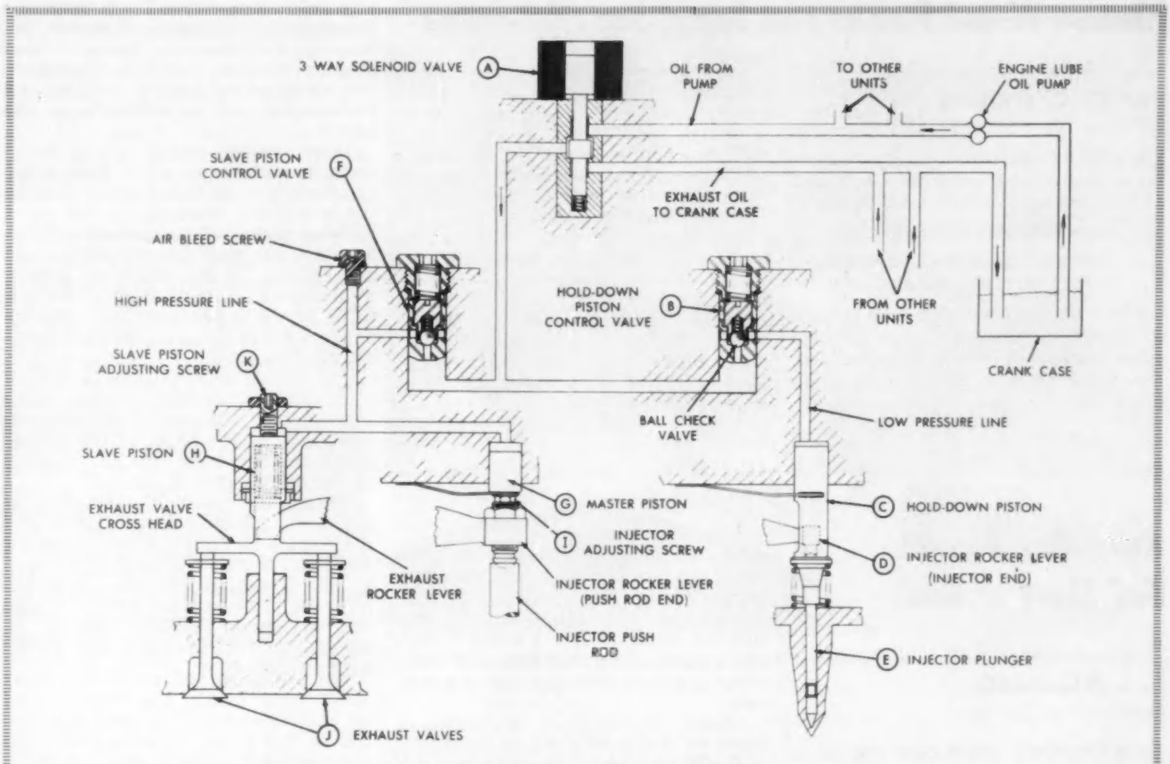


Fig. 1 — Hydraulic circuit of Jacobs Engine Brake.

Jacobs Brake Uses Diesel for Retarding

Based on paper by

C. LYLE CUMMINS, JR.

C. L. Cummins (Sausalito, California)

and G. S. HAVILAND

Clessie L. Cummins Division,
The Jacobs Mfg. Co.

THE JACOBS ENGINE BRAKE converts a power-producing diesel engine into a power-absorbing air compressor for retarding vehicles. Driver-actuated electric controls automatically energize a hydraulic circuit which functions to open engine exhaust valves near the end of each compression stroke. This action dissipates to the atmosphere the energy stored in the charge of compressed air in the cylinder before this energy can push the piston downward on the power stroke. In addition, whenever the electric control circuit is closed to make the conversion to a "compressor" the injector plunger is held seated eliminating the need for its lubrication. Thus none of this lubricating fuel can be injected into the combustion chamber.

Fig. 1 illustrates the method of opening the exhaust valve near the end of the compression stroke and of holding the plunger seated.

Energizing solenoid valve *A* permits engine lubricating oil to flow through control valve *F* and over both master piston *G* and slave piston *H*. Oil pressure overcomes a weak spring under master piston *G* and pushes the piston down until it maintains permanent sliding contact on a spherical surface on top of the injector rocker arm adjusting screw *I*. The spring holding the slave piston against its adjusting screw is strong enough to overcome the force created by even abnormally high lubricating oil pressure. When the injector rocker arm adjusting screw begins its upward travel (the injection cycle) master piston *G* is forced upward. The ball check valve in control valve *F* prevents oil flow out of the master-slave system, and hydraulic pressure forces the slave piston downward against the exhaust valve crosshead and opens the exhaust valves. At the start of exhaust cycle the exhaust rocker arm takes over from the slave piston.

When the solenoid valve is turned off, the system returns to normal operation by the action of the springs under the three pistons displacing the excess oil through the cap which controls the stroke of the control valves. With hot oil the brake becomes operative or inoperative in less than one-half second after switch actuation.

Energizing solenoid valve *A* permits engine lubricating oil to flow through control valve *B* to the chamber over holddown piston *C*. Injector rocker arm *D* does the work of forcing seated injector plunger *E*, and piston *C* merely follows down the spring retainer on the injector plunger *E*. Within a few cycles piston *C* is jacked down holding sealed injector plunger *E*. Even though the force created by the injector plunger spring is greater than the force of lubricating oil pressure on piston *C*, the ball check valve in control valve *B* prevents the piston from being forced up. Make-up oil enters the circuit when the plunger is held seated by the action of the rocker arm (during the normal injection cycle) as at this time the pressure over piston *C* drops below lubricating oil pressure.

■ To Order Paper No. 387A . . .
from which material for this article was drawn, see p. 6.

Filament-Wound Plastics Find Space, Sea Applications

Based on report by panel secretary
HARVEY G. SPENCER
North American Aviation, Rocketdyne Division

FILAMENT-WOUND plastic structures are being used for specialized air and sea applications because of:

1. High strength-to-weight ratio.
2. Low manufacturing cost compared to high-strength metal alloys.

Glass filament winding may be used in the on-site construction of orbiting space stations of almost unlimited size. Structures 50 ft in diameter or larger are within the present state-of-the-art.

Developmental prototypes of deep submergence filament-wound pressure vessels have been produced. Able to submerge more than 4000 ft, a large market is seen for these vessels. However, manufacturing processes and raw materials would have to be refined to produce these thick-walled vessels.

(Based on report of discussion at panel on Non-Metallic Pressure Vessel Manufacturing Techniques — Harvey Spencer, Rocketdyne Div. of North American Aviation, chairman; Wayne Werts, The Bendix Corp.; A. J. Wiltshire, Structural Fibers, Inc.; M. A. Nadler, Structural Materials Div.; Aerojet-General Corp.)

Reliability Results Fall Short of Goals

Based on report by panel secretary
L. J. REGGIARDO
Douglas Aircraft Co., Inc.

RELIABILITY RESULTS appear to be falling short of targets in many cases . . . despite requirements developed to enforce organized effort to meet high reliability levels. More accurate analysis and design, more effective prime contractor-supplier relationships, and more realistic manfacturing refinements should go a long way in alleviating present shortcomings.

Simple disciplines applied early in any program can lead to a higher level of reliability. But the engineer too often assumes that men, machinery, and materials are at an optimum. Some design leeway must be provided for human and mechanical frailties. The high rate of change caused by engineering errors (30% in one program) indicates a need for more accurate analysis and design to get a satisfactory end product on schedule at an acceptable cost.

Since the prime contractor buys much of his materials and equipment from others, an effective reliability control program is a must. Some suppliers have established programs which will assure the reliability of their products. The majority, however, need guidance and control from the prime contractor.

Manufacturing refinements are needed in turning out hardware. To get significant improvements, more effort must be applied to integrating human capabilities and the functions to be performed. Three essential factors must be considered: intelligence transfer, intelligence interpretation, and manual effection.

The commercial aircraft operators are as concerned with the economic impact of poor system reliability as the military are with inadequate weapons systems effectiveness. A better understanding of the interrelation of reliability and total operating cost is necessary.

(Based on report of discussion at panel on A Candid Look at Reliability — C. W. Andrews, Douglas Aircraft Co., Inc., chairman; Charles Kohler, Lockheed, Georgia; W. C. Hanna, Northrop Corp., Nortronics Div.; F. S. Nowlan, United Air Lines.)

Electron Beam Welds Join Mach 3 Materials

Based on report by secretary
K. E. KUSCHELL
Northrop Corp.

THE THERMAL BARRIER presented by Mach 2.5 to 3.0 requires new joining techniques and greater use of exotic materials. One way of joining these materials is by electron beam welding. Investigations reveal that all refractory materials as well as dissimilar metal-to-metal and metal-to-ceramic welds can be made by this process.

The high-power-density electron beam welding process features low energy absorption by the workpiece which minimizes distortion and damage to mechanical properties. Beam power, spot size, and spot position are controllable. Purity of the weld is achieved by welding in a vacuum. No foreign atoms are produced during welding.

The need to house the parts to be welded in a vacuum chamber imposes physical and economic limits upon application of the process. However, the movable electron gun has permitted smaller vacuum chamber dimensions and his simplified tooling, locating, and positioning the components to be joined.

Tests reveal that no material strength differences occur when using either the low- or high-voltage electron beam welder. Porosity is less of a problem when welding refractory materials than with the tungsten inert gas process. This results in greater weld ductility. Premachining of edges to be joined is necessary with the refractory materials to produce the tightest possible joint.

The prospects of welding outside of a vacuum chamber are currently being investigated. However, many problems exist such as the effect of the atmosphere on weld width and as a barrier to the electron beam itself.

(Based on report of discussion at panel on Electron Beam Welding — Aerospace Structures — Harold Smallen, Northrop Corp., chairman; E. G. Thompson, North American Aviation, Rocketdyne Div.; William Farrell, Sciaky Brothers, Inc.; J. W. Meier, Hamilton Standard Div., United Aircraft Corp.)

NEW Machining Processes Stage Consistent Advances

Based on Secretary's Report by
T. E. HUDSON
The Marquardt Corp.

A SIGNIFICANT improvement in drilling and tapping of small holes is one of several unusually interesting advances in technique to gain widespread attention recently. This development — now being investigated by a Southern California aerospace manufacturer — raised the drilling rate from 2-holes-per-min to 90-holes-per-min when applied to a complex small-hole job. At the same time, it increased the number of holes drilled from 48 to 1000. This process is a development in precise control of torque and speed of machine tool equipment.

In a slotting operation to which it was applied, this new process permitted sawing a 0.003-in. slot through 0.040-in. sheet attached to a wing member for a length of 20 ft. Here torque and speed control was applied to the saw blade and the movement of the wing member through the blade. The maximum measured tolerance on the width of the slot was 0.0004 in.

Existing drill presses were easily modified to provide the torque and speed control by addition of an analog computer controller system . . . and by installation of a d-c electric motor

— usually of a lower horsepower rating. (The torque level is usually lower than in manual drilling operations.) The analog computer controller senses the torque and maintains it at a constant level by controlling the speed of the motor and the feed of the drill. Application of this control to milling and turning operations is being conducted by several aerospace firms.

Electrochemical Machining Progress

Another unconventional metal removal process currently being improved is in chemical milling and electrochemical machining. Superalloys such as 15-7 PH and Rene 41 are being chemically milled in thicknesses down to 0.007 in. with ± 0.001 in. tolerance for complex parts to 13 ft square. Surface finishes to 30-40 rms are being attained. Refractory metals such as molybdenum, tungsten, tantalum, and beryllium have been successfully milled. Proper solutions of bath chemicals have reduced the evolution of hydrogen to levels as low as 0.5% of that previously experienced.

Development of electrochemical machining techniques also have progressed. Now these processes are competitive or cheaper than conventional machining where the parts are complex-contoured or where they have high hardness as machined. Up to eight times as much metal can be removed by ECM than by conventional machining for these complex shapes. However, when tolerances are close, ECM is slower.

On one forged part, for instance, production rates of 100 per day have been attained with two electroshaping machines at a much lower cost than with conventional machining. Tolerances as close as 0.001 in. can be held in simple holes. Also, complex holes with varying radii and fillets can be held to 0.010 in.

Generally, the "throwing power" of the electrical field can machine a part electrochemically at differential removal rates up to a ratio of 10 to 1. Chemical milling, however, removes the material at a relatively uniform rate on all surfaces except those masked off.

Substitution of chemically-milled or electrochemically-machined parts in high stress applications must be carefully reviewed, since conventional machined parts usually have surface stresses included, whereas electrochemically-machined parts do not.

(Based on report of discussion at panel on Metal Removal — Unconventional — W. L. Kaufman, chairman. Also serving on the panel, in addition to the panel secretary, were Cloyd Snovely, Sifco Metachemical, Inc.; E. J. Krabacher, Cincinnati Milling Machine Co.; and L. E. Bruce, U. S. Chemical Milling Corp.; Cloyd Snavely, Sifco Metachemical, Inc.; E. J. Krabacher, Cincinnati Milling Machine Co.; L. E. Bruce, U. S. Chemical Milling Corp.)

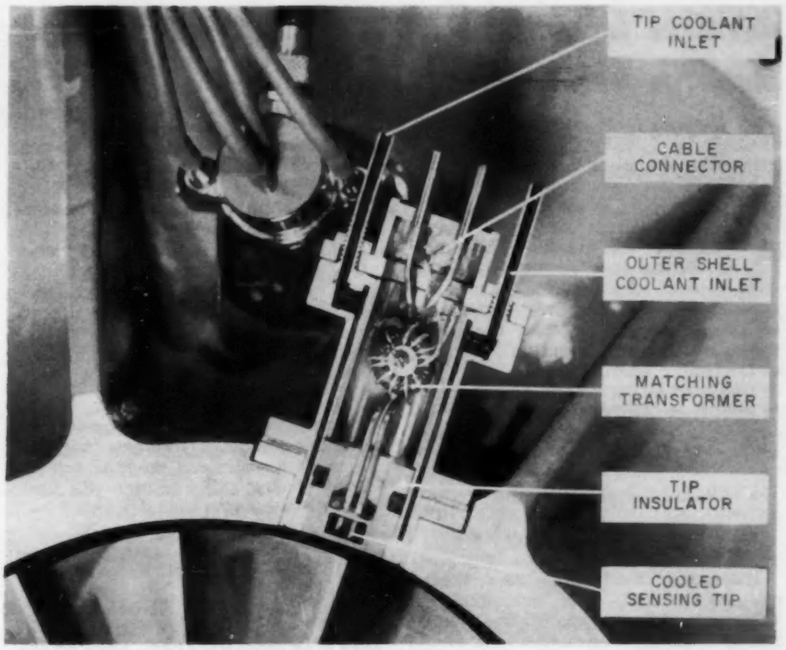


Fig. 1 — Cross-section of a double-cooled, capacitance-type, clearance pickup for turbomachinery.

Measuring Turbine Blade Running Clearance

Based on paper by

ALAN WARNICK, R. E. CONDIT, and J. R. SECORD

Ford Motor Co.

BLADE TIP clearance can be measured accurately in a turbine at gas temperatures up to 1700 F by use of a capacitance-type pickup.

The pickup must be artificially cooled to withstand high engine temperatures and to reduce changes of electrical parameters with temperature. Materials for critical parts of the pickup must be selected with regard to their performance over a wide range of temperature, and means must be provided to offset changes in calibration with temperature.

In the capacitive transducer, the capacitance between sensing element and surface to be measured is relatively independent of temperature. The elemental clearance transducer consists of a metal sensing disc approximately ¼ in. in diameter, flush with the inner surface of the shroud and insulated from it. The sensing disc and turbine blade form a capacitance which varies with the angular position of the blade and with the clearance. Variations of capacitance are converted to an electrical signal which is measured and displayed in terms of clearance.

Design of Pickup

Fig. 1 shows a cross-section of a pickup having a water-jacketed shell and a hollow, water-cooled tip. Water lines to the tip must be of insulating material such as silicone rubber, and the water must be reasonably pure to avoid additional loss factor. The pickup requires a 13/16-in. hole in the shroud. The arrangement shown is a working model and measures radial clearance in a display setup. A similar pickup, visible in the illustration, measures axial clearance.

When heat is applied to the sensing end of the pickup, only the annular-shaped volume between tip and outer shell becomes hot. The insulator remains cool adjacent to the tip and to the outer shell, thus temperature changes of volume resistivity and capacitance of the insulator are minimized. The inactive capacitance of the double-cooled pickup increases by approximately 0.5% for air temperature of 1400 F in the vicinity of the sensing tip.

■ To Order Paper No. 382A . . .
from which material for this article was drawn, see p. 6.

Advanced Techniques Aid Materials Quality Control

Based on Panel Secretary's Report by

G. W. HOWARD

Rohr Aircraft Corp.

ADVANCED TECHNIQUES in quality control include recently developed control of non-metallic pressure vessels; inspection techniques for controlling thermal protective materials; use of isotopes as inspection tools; and radiographic sensitivity.

Two interesting recent developments in quality control of non-metallic pressure vessels for use in final inspection are:

- ultrasonic equipment, and
- the probograph

Ultrasonic methods utilize special equipment and the principles of "Through Transmission" and "Pulse Echo." These techniques locate and outline the defect, determine its depth, and provide data for further evaluation.

The probograph provides a record of dimensional measurements in graph form. The entire operation of the probograph is controlled by a "flexowriter" 8-hole punched tape.

In the inspection of thermal protective materials, "hot" structure design philosophy stresses selection of materials suited to resist degradation of properties at elevated temperatures. Tools useful for elemental analysis are direct-reading and spectrographic-emission equipment in the visible, ultraviolet, and X-ray spectra. The neutron generator is also being developed in this area.

Length "wet" analysis techniques are being reserved for establishing standards for the emission instruments, accurate check analysis, and the elements of the lower atomic numbers that do not lend themselves to spectra evaluation.

X-ray diffraction and the electron microscopes are supplementing the light microscope in crystal structure and homogeneity evaluation at the microscopic levels.

End product testing in the nondestructive field employs ultrasonics, radiography, eddy current, and beta backscattering techniques to evaluate protective and ablative coating thicknesses and continuity.

"Gamma Radiography" is a standard accomplishment in use of isotopes for inspection. This technique is unique in that the source can have an almost mono-energetic output which is similar to a heavily filtered X-ray machine.

The radioactive isotope can be useful in leak detection in complicated structures. The item under test is slightly pressurized with a dilute radioactive gas which, when it leaks out, may readily be indentified with the leak.

Another not too well known application is the distribution of a weak, short-lived radioactive isotope in welding rod. When the weld is completed it is a simple matter to measure whether enough weld is present to give a full distribution of weld materials.

The most important and least understood factor affecting subject contrast is scattered radiation. Although scattered radiation can never be completely eliminated, a number of means are available for reducing its effect:

1. Cut-out diaphragms or mask mounted over or around the subject.
2. Where a cutout diaphragm would not be economical, packing barium clay around the specimen will serve the same purpose.
3. Sometimes it is found practicable to place the objects in aluminum or thin sheet-iron pans and to use a liquid absorber.
4. A convenient, effective arrangement is to surround the object with copper or steel shot having a diameter of about 0.01 in. or less.
5. Lead foil screens, mounted in contact with the film are, beyond a doubt, the most economical, convenient, and universally applicable means of combating the effects of scattered radiation.

(Based on report of discussion at panel on Quality Control — Advanced Techniques — W. J. Kennelly, Rohr Aircraft Corp., chairman; J. Hall, Budd Co., Instruments Div.; R. Reynolds, Eastman Kodak; J. E. Carton, Boeing-Aerospace Div.)

Toxic-Radioactive Hazards Demand Realistic Regulation

Based on report by panel secretary

R. R. FOUSE

Marquardt Corp.

COOPERATION between industry and government is the only real answer to control of radioactive and highly toxic materials. The complex problems arising from increasing use of hazardous materials in manufacturing processes must be countered by an increasing awareness of the hazards involved and realistic regulations governing their use.

The unique properties of many of the highly toxic and radioactive materials dictate their use in the nuclear-space age. In addition, many more are coming into use indirectly in the manufacture of more commonplace items. The number of industrial radioisotope users now totals almost 2000 and is increasing rapidly as new techniques are developed. Many of these applications are being developed through the Atomic Energy Commission as an economical use of the byproducts of nuclear power generation. The hazards involved in using these materials must be weighed against their advantages and every reasonable attempt made to reduce the hazards in the event their use is warranted.

As the first line of defense against industrial hazards, line supervision must be well informed concerning the dangers involved in the use of materials such as beryllium or radioactive cobalt, and they must be backed up by a well informed management team. Because of the wide variety of problems encountered it is usually necessary to contact technical societies, government agencies, or other industrial firms for information on a specific problem.

Close cooperation between line supervision, management, and outside contacts can minimize the amount of effort a newcomer to the field of hazardous materials must expend to insure safe working conditions. The experience of the Los Angeles City Health Department has shown that an exchange of ideas between industry and government is extremely valuable in maintaining an up-to-date well informed local agency. The recent decision by the State of California to take over regulatory functions in certain fields previously under the jurisdiction of the AEC will enhance the role of the local agencies.

(Based on report of discussion at panel on Cooperation Between Government and Industry Key to Control of Toxic and Radioactive Materials — S. V. Castner, Marquardt Corp., chairman; J. Hitch, U. S. Atomic Energy Commission; R. J. Foltz, North American Aviation, Atomics International; C. L. Senn, City of Los Angeles Health Department.)

DATA PROCESSING—
New Tool for Manufacturing Control

Based on report by panel secretary

W. M. SIMONS
Ryan Aeronautical Co.

INTEGRATED DATA PROCESSING TECHNIQUES are being used as a manufacturing control tool for:

1. Scheduling and performance reporting in electronics manufacture.

2. Controlling the supply of parts to manufacturers assembling F-104 fighter aircraft overseas.

Scheduling and Performance Reporting

Shop paper scheduled completion dates is a unique feature of a scheduling system employed at Hughes Aircraft.

Shop supervisors get separate listings on jobs currently in their department and jobs scheduled to their department for the next operation. The system provides for total integration of all scheduling and performance elements starting with the customer schedule. All components of manufacturing are reduced to one master schedule.

Reporting and feedback of schedule performance is on an exception basis; that is, only those items requiring action are examined and expedited. Advantages of the system are:

1. Changes in shop paper scheduling come about only by transmitting the changes to the computer. It isn't necessary to physically pick up the order in the shop to change the schedule dates.

2. Integration eliminates duplication of input transactions and records and eliminates discrepancies between production, material, and cost control records.

3. Output information is always consistant because it comes from a central common record.

Integrated data processing techniques are used in all elements of program and in plant scheduling on a level-by-level basis.

Controlling Supply of Parts

Integrated or electronic data processing techniques at Lockheed-California eliminate up to 80% of the manual processing of working paper. Utilization of an IBM 705 and IBM 305 RAMAC in controlling the supply of parts to foreign manufacturers assembling F-104 aircraft overseas has resulted in substantial savings in manual processing. The system produces:

1. Summarized, scheduled, shippable requirements from the Master Parts List.

2. Related documentation inherent with the procurement, receipt, release, shipment, and control of material.

The Master Parts List tapes are created and maintained by the Production Planning Department. Accomplishment of this task, with its exceedingly high volume, short-time spans, and need for accurate timely management reports, would be impossible without the aid of electronic data processing systems.

Future Data Processing Applications

A look into the future of data processing applications in the Avionics industry by General Electric resulted in the development of advanced techniques using decision structure tables, the essential element in TABSOL, A Tabular System-Oriented Language. (Decision structure tables describe complicated multivariable, multiresult decision systems in the manufacturing business.) Future application of techniques currently being used in the commercial electronics business will enable automatic conversion of customer specifications to standardized product design characterization — and to direct generation of shop order paper.

(Based on report of discussion at panel on Data Processing as a Manufacturing Control Tool—J. W. Schiefer, Ryan Aerospace Div., chairman — Dale Goudy, Hughes Aircraft Co., co-chairman; D. R. Musard, Lockheed, California Co.; W. F. Williams, General Electric Co.)

Cost Injection Needed in Early Design Stages

Based on Panel Secretary's Report by

WILLIAM R. MICKS
The Rand Corp.

ECONOMIC factors have widely-varying degrees of leverage in influencing selection of materials for aerospace applications. The variations are due:

- Partly to dictates of the physical world and the materials actually available.
- Partly to the planning and analytical processes industry uses to set goals and formulate courses of action.

Not much can be done to change the materials available. But significant improvement may be possible in our processes and formulations.

Often a specified goal is so marginal that the designer has a very limited choice of materials. Only a few will do the job — at least among those known to be available at the time of decision-making. In such cases, economic considerations are secondary.

But where a number of materials can compete with one and another economics do influence the selection. In motor cases, for example, several materials may be suitable.

In some instances, certain hardware components of a design have been optimized on a cost basis — rather than on a weight basis. But usually this is not the case. Infrequently are cost factors injected into the design process early enough to influence the overall system design. When cost factors are injected at the stage of exploratory design in aerospace system concepts, they can influence materials selection greatly — and benefit the end result proportionately.

Selection of materials affects cost chiefly through its effect on the vehicle design . . . on the vehicle's size for a fixed mission, for example. It affects manufacturing costs also. Quantity and production rates have significant implications for both materials selection and cost.

Other systems specification factors — which may indirectly influence materials selection — can affect cost significantly too. The requirement of interchangeability of motor cases — with its extremely close tolerances — is one example. The high cost of the interchangeability requirement should be weighed carefully in terms of its advantages versus its high cost.

Cost factors in selecting aerospace system materials are functions of the combination of design, material, manufacturing, and system operation. Continued efforts are needed toward optimizing the combination of these four on an economic basis.

(Based on report of discussion at panel on Economic Factors in Selection of Material for Aerospace Applications — Dr. M. A. Steinberg, Lockheed/Missiles & Space Co.; W. O. Wetmore, Aerojet-General Corp.; A. E. Green, Lockheed Co.; Lt.-Col. J. F. Clyde, Air Force Space Systems; W. R. Lucas, George C. Marshall Space Flight Center, NASA.)

NUMBER

2

Digest-listing of NEW and REVISED SAE Reports

Included are three new Aerospace Information Reports and one new Aerospace Recommended Practice.

THIS is the second in a continuing series of monthly digests of new and revised SAE technical committee reports. Covered are those approved by the four ground and aerospace Councils of the SAE Technical Board in October.

NEW: **LUBTORK — THE PROCESS OF LUBRICATING AND TORQUING THREADED ASSEMBLIES (ARP 698)** — Contains recommendations for lubricating parts and torquing threaded assemblies where Lubtork is specified. Covers lubricant types, conditions of lubrication, and torque-tension relationship of lock nut and bolts as required for desired preload. (Committee A-5, Aircraft Wheels, Brakes, Skid Controls and Axles)

NEW: **ELECTRONIC EQUIPMENT THERMAL DESIGN CONCEPTS FOR HIGH MACH NUMBER AIRCRAFT (AIR 728)** — Will guide electronic manufacturers on the design approach to be used in producing equipment which can operate with satisfactory life and reliability when subjected to the environment associated with supersonic aircraft performance. Outlined are general design concepts considered the minimum acceptable standards for use in electrical and electronic equipment. (Committee A-9, Aerospace Environmental Systems)

NEW: **SPARK ENERGY MEASUREMENTS USING OSCILLOSCOPIC METHODS (AIR 77)** — An oscilloscopic method of measuring energy in separate spark discharges as an indication of the useful energy available to cause combustion. (Ignition Research Committee)

NEW: **OSCILLOGRAPHIC METHOD FOR MEASURING SPARK ENERGY CAPACITOR DISCHARGE IGNITION SYSTEMS (AIR 91)** — Direct measurement of the voltage across ignition plug electrodes and the current flowing through the spark plasma is the technique used to measure efficiency in ignition systems. It can be used where internal curretry components are not accessable. (Ignition Research Committee)

"New" Seating Manual Reflects Broad Revisions

A COMPLETELY revised SAE Seating Manual (TR-135) is approximately twice the size of the original version. Prepared by the Automotive Seating Subcommittee of the SAE Body Engineering Committee, it now includes:

- Expanded coverage of automobile seating practice in seat adjusters, seat frames, spring assemblies, pad supports, paddings, seat coverings and trim fastenings.
- Clarification and expansion of seating terminology through the use of drawings and illustrations.
- Presentation of typical seat assembly tests to determine: load distribution, fatigue life, static rate of springs, etc.

The Automotive Seating Subcommittee is composed of engineering personnel engaged in the manufacturing or testing of automotive seats and their components. The revision was initiated under D. J. Schrum, present Body Engineering Committee chairman. The current chairman of the Automotive Seating Subcommittee is John Haviland. (To order, see page 6.)

New SAE Publication Covers Automotive Painting Practices

ALL aspects of automotive painting are contained in a new SAE Handbook Supplement, TR-191, *Automotive Painting Practices*. The 10-page booklet combines the knowledge of industry experts on everything from cleaning surfaces to final color coating. Included is information on materials and how to paint steel, aluminum and other nonferrous metals. Prepared by Nonmetallic Materials Committee, the report may be ordered on page 6.

SAE NEWS

A report from the Board of Directors

At the September 15, 1961, meeting of the Board of Directors, the following actions were taken:

APPROVED

Letter to be sent to J. H. Pitchford regarding **INVITATION TO JOIN FEDERATION INTERNATIONALE DES SOCIETIES d'INGENIEURS DES TECHNIQUES DE l'AUTOMOBILE (FISITA) (Summary 1)**

INITIATION FEES OF SAE FACULTY ADVISORS BE WAIVED upon election to membership in the Society **(Summary 2)**

PROCESSING OF MEMBERSHIP APPLICATIONS (Summary 3)

Constitution Committee to **REDRAFT LANGUAGE OF C 42 (Summary 5)**

SIGNATURE OF RAYMOND J. McGOWAN, Comptroller, be substituted for that of John C. Hollis **(Summary 6)**

Necessary steps be taken to **PROCESS THE PROPOSED AMENDMENTS TO THE CONSTITUTION AND BY-LAWS (Summary 4)**

Renewal of **LOCAL UNITS TO FUNCTION AS SAE GROUPS** for one year **(Summary 7)**

Amendment to the **RULES OF THE WRIGHT BROTHERS MEDAL BOARD OF AWARD (Summary 8)**

ELECTION OF 70 applicants to membership in the Society **(Summary 10)**

GRADE TRANSFERS OF 9 members **(Summary 10)**

Proposed **"GUIDES FOR DETERMINING QUALIFICATIONS OF MARINE ENGINEERS FOR MEMBERSHIP IN THE SOCIETY" (Summary 10)**

Date of **ANNUAL BUSINESS MEETING (Summary 10)**

Issuance of **PROXY TO SAE-NOMINATED DIRECTORS ON THE CRC BOARD (Summary 10)**

CONFIRMED

Affirmative ballot on **AMENDMENTS TO THE ASA BY-LAWS (Summary 10)**

Presidential appointments of **PUBLICATION STUDY COMMITTEE PERSONNEL** and **SAE-NOMINATED DIRECTORS ON CRC BOARD (Summary 9)**

REJECTED

Twenty-six applicants for **MEMBERSHIP (Summary 10)**

TRANSFER IN GRADE of one member **(Summary 10)**

---

(1)

Invitation to Join Federation Internationale des Societies d'Ingenieurs des Techniques de l'Automobile (FISITA)

The Board of Directors expressed appreciation to FISITA for the cordial invitation to join that organization and agreed with the thought that there is a growing need for cooperation and understanding among automotive engineers of all countries. In the reply approved by the Board of Directors, Dr. Kucher expressed the opinion that several events within the next year would go a long way toward improving and increasing cooperation between engineers in the United States and those in the constituent bodies of FISITA.

(2)

Waiver of Initiation Fees for Faculty Advisors

As recommended by the Executive Committee, the Finance Committee, the Sections Board, the Student Committee and the Membership Committee, the Board of Directors voted that the initiation fees of SAE Faculty Advisors be waived upon their election to membership in the Society and that no waiting period be required.

(3)

Processing of Membership Applications

The Board of Directors approved the recommendation of the Executive Committee and the Membership Grading Committee that applications from candidates who are qualified for election to Member grade of membership without question be sent to a single senior member of the Membership Grading Committee for review. The recommendation carries the proviso that if this member questions the application it then revert to the customary practice of receiving screening by two or more members of the Committee.

The Board of Directors requested the Constitution Committee to develop appropriate amendments to the Constitution and By-Laws allowing the Membership Grading Committee to take final action on membership applications, as recommended by the

---

"A summary report of the actions of the Board of Directors shall be published in the next following issue of the official publication of the Society." . . . from C 6 of the SAE Constitution.

Membership Grading Committee, while at the same time preserving the dignity and prestige of Board of Directors' participation in the election to membership of all applicants.

The recommendations of the Membership Grading Committee were the result of a study made by the Committee on the time required to process membership applications. This project grew out of the desire of the Directors to reduce the length of time it now takes to process applicants to the point where they are elected to membership.

(4)

Proposed Amendments to SAE Constitution and By-Laws

The Board of Directors endorsed a report of the Constitution Committee including proposed amendments to the Constitution and By-Laws and directed that the necessary steps be taken to process the proposals.

The Constitution Committee's report included amendments needed to carry out Board of Directors' approval of amending the Constitution and By-Laws to include reference to the Society's initials; to specify formally the nature of the SAE emblem as to design, shape and color; to reword the section on qualifications for Associate grade; to include a new paragraph in the Constitution on distribution of assets in the event of dissolution, to bring the Constitution and By-Laws up to date with current practices; to delete language that was necessary during the transitionary period, to put the Planning for Progress proposals into effect, and for clarification.

The processing of amendments to the Constitution involves printing in the November Journal, submission at the Annual Business Meeting in January and subsequently by letter ballot to the voting members. Amendments to the By-Laws may be acted upon by the Board of Directors by presentation at two meetings of the Board.

(5)

Proposed Amendment to C 42

The Directors requested that the Constitution Committee re-draft the language of C 42 to clearly indicate that only those members of the Board of Directors who had served a full three-year period were not eligible for re-election to the same office. This request was brought about by the fact that at the January, 1961, meeting of the Directors there had been difficulty in interpreting section C 42 of the Constitution in attempting to take action to fill the vacancy created by the election of Dr. Kucher to the Presidency.

(6)

Finance Committee Report

The Board of Directors voted to receive the July 31, 1961, Financial Statement and approved of the Finance Committee's recommendation on the budget for the 1961–1962 fiscal year. It was noted that the over-all income will total $2,266,930 as against the over-all expense of $2,214,005. Of the excess income of $52,925, $43,000 is anticipated as earnings from investments, $5,220 is expected to be derived from member service operations and $4,705 from the Cooperative Engineering Program.

The Board of Directors enthusiastically endorsed the recommendation of the Finance Committee that a suitable message be sent to Mr. John C. Hollis, who had just retired from the SAE staff, expressing appreciation of the fine job he had done during his seventeen years of service. The Finance Committee, in making its recommendation, expressed high regard for Mr. Hollis as a person as well as a member of the staff.

The retirement of Mr. Hollis made it necessary to substitute another staff signature for the Society's various bank accounts. To accomplish this, a suitable resolution was passed, authorizing that the signature of Raymond J. McGowan, Comptroller, be substituted for that of John C. Hollis, Manager of Administrative Division, as an approved staff signature for the following SAE bank accounts: General, Payroll, Western Branch Office, Detroit Technical Office, Special Tax, Investment Advisory, and the Manly, Springer and Clarkson Funds Savings Accounts. Mr. McGowan's signature has been authorized for the Petty Cash account since 1954.

(7)

Continued Recognition of SAE Groups

The Directors authorized continuation of the following Groups for one year through September 30, 1962: Alberta, Salt Lake, South Texas and Williamsport. This action is in keeping with the SAE By-Laws, which state: "Authorization of a local unit to function as an SAE Group shall be for a one-year period, such authorization to be renewable annually at the discretion of the Board of Directors."

(8)

Amendment to Wright Brothers Medal Rules of Award

The Board of Directors approved of the recommendation of the Wright Brothers Board of Award that the Rules of the award be amended to broaden the scope of the award to include aerospace subjects and that the language be amended accordingly. The first award under these rules is to be made for the calendar year 1961.

(9)

Presidential Appointments

The Directors confirmed President Kucher's appointment of the following:

(a) Publication Study Committee Personnel

Leonard Raymond, Chairman — Chief Automotive Engineer-Research, Socony Mobil Oil Company, Inc.

P. F. Allmendinger, Director of Engineering, Electric Autolite Co.

F. B. Esty, Vice-President, Chief Engineer, Wisconsin Motor Corp.

W. F. Ford, Assistant Director, Petroleum Products Division, Continental Oil Company

D. E. Manning, Senior Design Metallurgist, Pratt & Whitney Aircraft Division, United Aircraft Corporation

V. G. Raviolo, Executive Director, Engineering Staff, Ford Motor Co.

T. B. Rendel, Assistant to Vice-President, Manufacturing, Shell Oil Company

T. L. Swansen, Vice-President, Ladish Co.

R. P. Trowbridge, Director, Engineering Standards Sec-

continued on next page

A report from the
Board of Directors

. . . continued

tion, General Motors Corporation

(b) SAE-Nominated Directors on the CRC Board

H. F. Barr, Chief Engineer, Chevrolet Motor Division, General Motors Corporation

G. E. Burks, Vice-President, Research and Engineering, Caterpillar Tractor Company

G. J. Huebner, Jr., Executive Engineer, Research, Chrysler Corp.

C. C. Ross, Vice-President, Engineering, Aerojet-General Corp.

(10)

Other Board of Directors' Actions

- Authorized President to appoint a committee to study and develop a policy which will lead to a coordinated plan for recognizing the services of members making important contributions to SAE.
- Approved the proposed "Guides for Determining Qualifications of Marine Engineers for Membership in the Society."
- Elected 70 applicants to membership in the Society, approved of transfer of grade of 9 members, denied membership to 26 applicants and denied the transfer of grade of 1 member.
- Voted to schedule Annual Business Meeting for Monday, January 8, 1962, at 9:00 A. M. at Cobo Hall, Detroit, Michigan, during the 1962 Automotive Engineering Congress and Exposition (Annual Meeting), January 8-12, inclusive.
- Approved of the issuance of the proxy to SAE-Nominated Directors on the Coordinating Research Council Board for use in casting the Society's ballot at the Annual Meeting of the CRC. The date of the Annual Meeting is to be determined later.
- Confirmed President Kucher's affirmative ballot on behalf of SAE as a member body on amendments to the American Standards Association's By-Laws.

SAE National Meetings

1962

January 8–12
Automotive Engineering Congress and Exposition
Cobo Hall, Detroit, Mich.

March 12–16
Automobile Week
(combined National Automobile and Production Meetings)
Sheraton-Cadillac, Detroit, Mich.

April 3–6
Aeronautic
(including production forum)
Hotel Commodore, New York, N.Y.

June 11–15
Summer
Chalfonte-Haddon Hall, Atlantic City, N.J.

August 13–16
National West Coast
Biltmore Hotel, Los Angeles, Calif.

September 10–13
Farm, Construction, and Industrial Machinery
(including production forum and engineering display)
Milwaukee Auditorium, Milwaukee, Wis.

October 8–12
Aeronautic and Space Engineering and Manufacturing
(including manufacturing forum and engineering display)
The Ambassador, Los Angeles, Calif.

October 29–November 2
Combined National Fuels and Lubricants; Powerplant and Transportation Meetings
Bellevue Stratford, Philadelphia, Pa.

PAN AMERICAN Day to Star at 1962 SAE Automotive Congress

Swain

Ramirez

MEXICO will be represented at both morning and afternoon sessions of the PAN AMERICAN DAY which will be a part of the 1962 SAE Automotive Engineering Congress at Cobo Hall January 8–12. (Pan American Day will be January 11.) Carlos F. Ramirez, manager of personnel development department, Ford Motor Co. S.A., will present a formal paper at the morning session in which he will discuss "Developing Automotive Suppliers in Mexico." In the afternoon, he will participate in the discussion following Dr. T. Keith Glennan's address on "Engineering Education in Six South American Countries."

Glennan, now president of Case Institute of Technology, will bring to the meeting ideas and conclusions reached from a survey which he recently completed under the sponsorship of the Council for Higher Education in the American Republics (CHEAR) and the Carnegie Foundation.

Chairman at the Glennan session will be J. J. Mikita, technical manager, Petroleum Chemicals Division, E. I. du Pont de Nemours & Co., Inc. SAE Past-President A. T. Colwell will introduce Dr. Glennan . . . and at this same session Prof. W. Leighton Collins, secretary, Society for Engineering Education, who also has returned recently from a study tour of South America, will give his observations on engineering education in South America.

Stephen A. Girard, president, Willys Motors, Inc. will open the Pan American Day event with a welcome to the international audience. The morning session will be chairmanned by Alaric Paris, Mercedes-Benz do Brasil S.A.

Four original articles are now scheduled for publication along with the Pan American Day formal papers . . . in a booklet to be available at Cobo Hall on January 11. Besides the previously-announced article on vehicle production in Latin America by Joseph K. Van Denburg, Jr., the booklet is now scheduled to include:

- **"The Pan American Way" by Robert O. Swain,** International Road Federation — dealing with the character and extent of highways in South America and Mexico.
- **"Pan American Fuels and Lubricants" by Charles B. Kass, Ethyl Corp.** — telling of types, regulations and performance problems, including facts about the blending situation.
- **"Engineering Education in Mexico" by Carlos F. Ramirez,** Ford Motor Co. S.A.

Chairman T. B. Rendel of SAE's International Information Committee — under whose auspices Pan American Day is being developed — is arranging to have christened "The Pan American Lounge" one of the attractive lounges which are planned within the Exposition area at this year's SAE Automotive Engineering Congress and Exposition.

NEW Brake Road Test Code Ready for January Session

Chairman Ralph Super

A NEW SAE Brake System Road Test Code — SAE J786 for trucks and buses will be ready for distribution at a January session at Cobo Hall, where speakers will elaborate on the code, explain why it is needed, and how it will be used. The code, designed to be an SAE recommended practice, establishes a uniform procedure for the level road test of the brake systems of all weight classes of trucks and buses. The session — at which Rockwell-Standard's Ralph Super will preside — will be one of the 67 scheduled for the 1962 SAE Automotive Engineering Congress and Exposition at Cobo Hall in Detroit, Jan. 8–12.

The plan is to have available at this Brake Code session in a single publication the presentations made at the session, as well as the code itself.

Developed by Subcommittee VII of the SAE Brake Committee, the code recognizes only two weight classes of trucks and buses: LIGHT — 10,000 lb gvw or less; MEDIUM AND HEAVY — over 10,000 lb gvw. It establishes brake system capabilities with regard to:

- deceleration in fpsps vs input, as affected by vehicle speed, brake temperature, and usage.
- lining characteristics and life.
- drum characteristics and life.

Included in the code are sections on instrumentation, test preparations, test procedure, and report forms and graph sheets. After development and approval by Subcommittee VII, the code will become an SAE recommended practice when the Automotive Council of the SAE Technical Board approves it. Chairman of Subcommittee VII is Ralph Super. Serving with him on the subcommittee are:

Vice-chairman B. W. Klein of Marshall-Eclipse; A. G. Beier of IHC; W. T. Birge of Kelsey-Hayes; J. C. Black of Thermoid; B. B. Brombaugh of Inland; C. A. Carlson of IHC; D. P. Fisher of Chevrolet; R. A. Goepfrich of Bendix Products; H. P. Hayes of Ford; F. W. Hudson of GMC Truck & Coach; R. W. Lange of American Brake Shoe; R. L. Lewis of Warner Electric Brake & Clutch; C. L. Meserve of Johns-Manville; R. R. Moalli of Raybestos-Manhattan; R. B. Palmer of Ford; S. G. Tilden of Permafuse; E. E. Wallace of Wagner Electric; Dean Williams of H. K. Porter; and E. G. Zipp of Chrysler.

1962 SAE Automotive Engineering Congress and Exposition

Isbrandt

Kittler

MORE THAN 150 PAPERS will be read at the 67 technical sessions scheduled for the 1962 SAE Automotive Engineering Congress and Exposition at Detroit's Cobo Hall next January 8–12.

Milton J. Kittler, executive vice-president, Holley Carburetor Co., is Operations Committee chairman for this year's meeting, a post held last year by Chrysler's Paul Ackerman.

Ralph H. Isbrandt, director of automotive engineering and research, American Motors, is carrying on for the second year as chairman of the Exposition Advisory Committee. "It looks as though there will be more than 300 companies in the Cobo Hall display this year," Isbrandt predicted last month, when 70% of the available display space had already been contracted for.

Official Notice

The Annual Business Meeting of the members of the Society of Automotive Engineers will be held on Monday, January 8, 1962, at 9:00 a.m., at Cobo Hall, Detroit, Michigan, as part of the 1962 SAE Automotive Engineering Congress and Exposition (Annual Meeting).

SAE Letters from Readers

From:
Harvey A. Mylander
Faculty Advisor,
SAE Student Branch
Kellogg-Voorhis Campus
California State Polytechnic College
Pomona, Calif.

Dear Editor:

On behalf of our Student Branch at Cal Poly, Pomona, we wish to thank you for the full-page write-up of our Spring economy run. We are using this as a display item to create interest in signing up students for this year's activity in SAE.

Many thanks for your interest in our project.

From:
James M. Roy
9078 Northlawn
Detroit 4, Mich.

Dear Editor:

I would like to inform you that I have left engineering to enter the teaching field. By preference, I would continue my affiliation with SAE, but financial circumstances do not permit. So, it is with regret that I have let my membership lapse.

I have been working toward a Masters Degree and this leaves me very little time for outside activities. It is with expectation, though, that I look forward to renewing my membership in the future.

I can only say that the wealth of information that has been available to me through the Society and my affiliation with engineering and the SAE has given me a wonderful background to bring into the teaching field.

Wright Medal Rules Modified by SAE Directors

WRIGHT BROTHERS MEDAL award rules have been modified to admit to competition papers dealing with spacecraft as well as those dealing with aircraft . . . also admitted now are papers dealing with **operation** of spacecraft and aircraft, as well as those concerned with aerodynamics or structural theory, research, and construction.

Other changes make mandatory a unanimous decision of the judges (Board of Award) in selection of a winning author. In addition, the rules now provide that: "These rules may be amended at any time in harmony with their general intent and purpose by the Board of Directors of the Society."

SAE Consultants

IF YOU DESIRE to do consulting work, the SAE CONSULTANTS bulletin will place your qualifications in the hands of over 1,000 prospective employers. Members who were listed in the 1961 bulletin need to take no action at this time. They will hear directly from the Placement Service about their continuance.

This program provides leads you would not otherwise have and is a not-to-be-missed opportunity.

Write SAE Placement Service, 485 Lexington Avenue, New York 17, N. Y. The CLOSING DATE for the 1962 issue is DECEMBER 31, 1961.

SAE's CEP NEWS

COOPERATIVE ENGINEERING PROGRAM

CRC REPORTS Work on 44 Projects; 30 Subjects

THE COORDINATING RESEARCH COUNCIL — of which SAE and American Petroleum Institute are sustaining members — was working on 44 individual projects dealing with 30 separate subjects at the end of its 1960–1961 fiscal year last June. The organization initiated projects last year covering such diverse subjects as aircraft fuel tank corrosion, diesel exhaust gas, and outboard fuel and lubricant test techniques. In addition, it expanded several test programs to meet the continuing demands of industry and the Military Services for improvement in performance of fuels, lubricants, and related equipment. CRC is now expending more than 54% of its activity for the Military Services. It now serves the Air Force, U. S. Navy Bureau of Ships, U. S. Army Ordnance Corps, and the U. S. Navy Bureau of Naval Weapons.

Among Current Projects

One major effort of a CRC Group is to extend the standard CFR Fuel Coker within the high temperature region. This is part of a project looking toward development of suitable equipment and test techniques for evaluating hydrocarbon fuels and/or fuel systems materials intended for use in high performance aircraft or components. Results are said to be promising from a concurrent test program to develop a small test rig for predicting thermal stability for fuel performance, without resorting to the larger and more expensive full-scale High-Temperature Research Fuel Coker.

In another area, CRC has completed evaluation of a small-scale rig unit known as the CRC Water Separometer, and of a corresponding laboratory test technique. Included is a short test program to establish standard reference fluids for checking the condition of equipment. . . . In general, the laboratory technique appears to predict the effect of additives on jet fuel filter coalescer elements and their efficiency for water removal. The validity of the test has been confirmed by full-scale systems.

Currently also, a small group of aircraft and petroleum representatives is being formed under CRC auspices to reach agreement on the problem of providing a specific airframe referee fuel or fuels for use in tests aiming at control of corrosion in fuel tanks of turbine-powered aircraft. A series of round-robin tests are contemplated, using a technique furnished by an aircraft company.

Among projects in the diesel area is one in which a CRC Advisory Group is cooperating with representatives of the Massachusetts Institute of Technology in a fundamental study of compression-ignition combustion. The project will use the rapid compression machine developed at MIT, which simulates one stroke of a compression-ignition engine. Requested by the Ordnance Department, this project is being financed by a grant from the National Science Foundation.

In the motor vehicle and equipment sector, current projects range over wide areas. They include:

- a brief program to evaluate the significance of the hot-starting technique involved in the work of the CRC-Motor Committee.
- devising of procedures and tests to be applied to fuels and elastomeric containers or transporters for the fuels.
- repetition of the annual CRC statistical-type national survey of the distribution of octane-number requirements of current domestic model passenger cars.
- development of tests to predict functional seal performance in actual operation.

"Considerable progress" is reported by the group studying the interrelationship of power-transmission and power-steering units and their fluids. But additional tests are being conducted to further improve the reproducibility of the research technique for determining the oxidation resistance and thermal stability of power-transmission fluids (CRC designation L-39). Being considered for further study also are friction studies and fluid evaluations in a transaxle unit.

A final report, soon available, will cover development of a bench test for measuring the low-temperature viscosity of power-transmission fluids which will give results in correlation with full-scale transmission performance.

Technishorts . . .

RATING OF COMMERCIAL VEHICLE BRAKES for registration purposes will be the subject of an SAE Recommended Practice now being developed by the Brake Committee. The proposed report would provide industry with a way of complying with regulatory requirements for rating commercial vehicle brakes. Its development was prompted by a request from the Motor Truck Committee of the Automobile Manufacturers Association.

ROLLER CONTACT FATIGUE — Development of fundamental data on the effect of metallurgical variables on rolling contact fatigue associated with sliding is the goal of a pilot test program being undertaken by Division 33 — Gear Metallurgy of the Iron and Steel Technical Committee. The purpose of this program is to determine the engineering utility of a gear roller test machine which has been developed by Caterpillar.

Rambling through

Fred L. Helbush, vice-chairman of Hawaii Section.

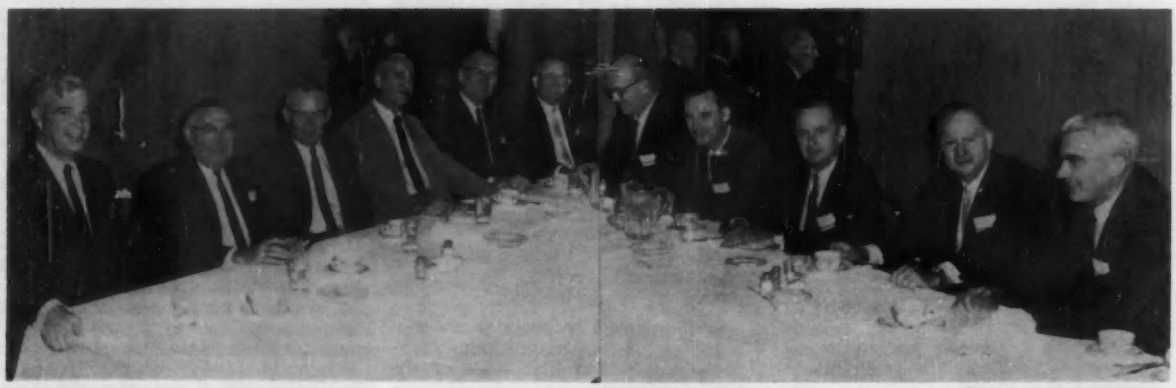
HAWAII SECTION members now are well informed about what happens to sugar before it reaches the mainland for refining. Touring the Oahu Co.'s sugar mill, the group viewed the details of processing sugar cane into raw sugar. Growing the sugar on 10,000 acres with a work force of 800, the mill represents an investment of one and one quarter million dollars. The time and work force required has been cut down by mechanization, such as a new automatic sugar cane harvester which cuts the cane, cleans off the leaves, and cuts the cane into short lengths which are then elevated into a trailer truck. Several tons of water are used to produce one pound of sugar.

CHICAGO SECTION'S SOUTH BEND DIVISION at its first technical meeting of 1961–62, honored T. A. Scherger upon his retirement from Studebaker after 35 years of service. Scherger was technical chairman of the meeting.

The meeting could have been called "Chairman Night," because so many Chicago Section past-chairmen were in attendance to help Scherger, himself a past-chairman, celebrate retirement. Also in attendance were student guests — representatives of three of South Bend's High Schools, who were able to hear Harold R. Johnson present "Lark Overhead Valve Six Cylinder Engine," which was co-authored by Scherger. . . .

CENTRAL ILLINOIS SECTION also found that young people could enjoy a highly technical speech when one member brought his high school-senior daughter to hear H. V. Watts speak on "Radioisoptopes in Science and Industry." Use of radioisotopes as an engineering tool has no limits, according to Watts, and the extent of the use is dependent upon the ingenuity of the user. The rigors of initial training, licensing procedures, health safety and high cost of application are largely responsible for the relatively small industrial application of radioisotopes up to the present.

OUTBOARD ENGINES started the 1961–62 season for **PHILADELPHIA SECTION.** In a talk on design, fuel, and lubrication factors, Section members were told that engine designers aim for increased out-put per unit weight and size, with reasonable cost and reliability of the power plant. The major operational difficulties with outboard engines are plug life and pre-ignition. Dr. G. H. Millar, McCulloch Corp., gave the talk to the Section.



SOUTH BEND DIVISION MEETING, (left to right), P. J. Sperry, Chicago Section chairman, E. O. Wirth, Chicago Section past-chairman, M. P. de Blumenthal, Chicago Section past-chairman, P. Mueller, Section Secretary, O. A. Brouer, Section past-chairman, T. A. Scherger, meeting technical chairman, Chicago Section past-chairman, W. R. Williams, South Bend Division vice-chairman, H. R. Johnson, speaker, T. H. Thomas, South Bend Division past vice-chairman, E. Hendrikson, Section past-chairman, J. MacNamara, South Bend Washington High School principal.

the Sections

Lady Astonaut Jerrie Cobb

LADY ASTRONAUT Jerrie Cobb highlighted a technical session at **DETROIT SECTION's** White Sulphur Springs meeting. She told her experiences as the first woman to complete successfully the testing program required of candidates for space flight. She favors use of women as astronauts as soon as possible. Miss Cobb is associated with Rockwell Standard's Aero-Commander, Inc.

At the same session Secor D. Browne, Browne and Shaw Co., Inc., discussed the competitive struggle for leadership in the exploration and conquest of space. The discrepancy between our knowledge of man's behavior pattern and our fast growing technological and engineering ability was the topic of another technical session, "Designing for People." Dr. Paul M. Fitts, Professor of Psychology at University of Michigan, made the principal address, "A Review of Man-Machine-Environment Systems." His intention was "to clarify the interaction between the sciences that deal with people, and to point up some unsolved problems and some unique opportunities in areas of man-machine compatibility."

THE NEW ATLANTA MUNICIPAL AIRPORT TERMINAL was the scene of one of **ATLANTA SECTION's** meetings, at which members divided into three groups to inspect various operations of the airport . . . behind-the-scenes operations of the airlines including baggage handling facilities, the jet overhaul facility, and the Federal Aviation Agency air route traffic control center from which all air route traffic in the Southeast is directed. Each group was sure it had taken the best tour, it was reported. "And each, undoubtedly was correct."

NEARLY 200 PEOPLE toured the Cleveland Graphite Bronze Plant, and heard the story of the "spark-pump" at a recent **CLEVELAND SECTION** meeting. Product demonstrations, refreshments, plant tour, dinner, illustrated talk, and discussion panel comprised the program. The Piezoelectric ignition system for small engines ("spark-pump"), is extremely simple and does away with magneto, points, and coil, while offering outstanding advantages from an operating standpoint. Lawn mowers equipped with the spark-pump were cutting grass in tempo for the observation of the Cleveland Section members and guests.

"Designing for People" at White Sulphur Springs meeting. (Left to right), Henry Mika, Ford Motor Co.; B. W. Bogan, chairman of the three day meeting; Dr. Paul Fitts, Professor of Psychology; Dr. Peter Kyropoulos, General Motors Corp., chairman of the session.

Rambling through the Sections

. . . continued

TWELVE THOUSAND PEOPLE who were killed last year in roadside accidents might be alive today had the roadside shoulders been designed for safety, according to General Motors' K. A. Stonex. Stonex told **INDIANA SECTION** that the removal of roadside obstacles and the redesign of signs and light posts can improve the "safety" of collisions. Tripod type light posts can be made of thin wall tubes which will collapse on impact and offer minimum resistance to the vehicle. He indicated that accidents cost the nation $20,000 to $30,000 per mile of highway, which was the cost per mile to remove the obstacles and correct the shoulders and ditches at GM Proving Ground.

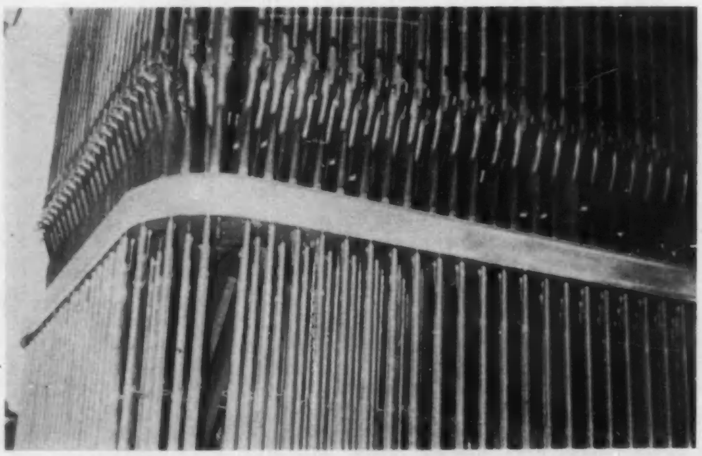
A HIGHLY SUCCESSFUL SAE rally and economy run was conducted last spring by the student chapters at Fenn College and Case Institute of Technology under the auspices of **CLEVELAND SECTION.** All concerned are hopeful of another such program for this year. SAE Enrolled Students were also enthusiastic participants in Pro-Amateur Week during which they were guests of engineers at various plants.

R. G. LETOURNEAU, recipient of the Elmer A. Sperry Award (see p. 109, November Journal), told **TEXAS SECTION** recently, that when he first began to work with construction equipment, two men could move three tons of dirt 2 mph with one machine, but that now, one man can move 150 tons of dirt 20 mph with one machine. Seventy-three-year-old LeTourneau advised younger members of the industry: "Work is play if you like your job, and anyone desiring success must be willing to work more than eight hours a day."

THE FIRST FALL ACTIVITY engaged in by **ST. LOUIS SECTION** was a tour of the maintenance shops and traffic control center of the St. Louis Public Service Co. The outstanding cleanliness and mechanical care given the large fleet of buses used by the firm is often discussed by the public as well as interested business people. The Section also visited the traffic control center, which shows the location and timing of all buses and street cars in the St. Louis Public Service System at any given moment.

SOUTHERN NEW ENGLAND SECTION members and their sons and daughters toured Springfield Armory and its historic museum of small arms. Here, the operation of a multi-barrel machine gun of an earlier day is explained by the group's official guide.

Section members Al Marchetti and Frank DeLuca observe the armament on display at the museum.



Stack of rifles referred to as a pipe organ in Longfellow's poem, written following his visit to Springfield Armory.

NORTHERN CALIFORNIA SECTION speaker, H. V. Lowther, answering a question following his presentation of "Preignition Studies in Two-Stroke Gasoline Engines."

SACRAMENTO-STOCKTON DIVISION Chairman W. M. Mason congratulating speaker John A. Miller.

SOUTH BAY DIVISION Chairman W. H. Moranda (left); D. R. Worn, meeting technical chairman; and Dr. Donald T. Perkins, guest speaker.

ASHLESS DETERGENT oils, both in heavy duty and automotive service, will be in universal use within a very few years, predicts California Research Corp.'s John A. Miller . . . "and they don't contribute to engine octane requirement increase," he told a meeting of the **SACRAMENTO-STOCKTON DIVISION** of the **NORTHERN CALIFORNIA SECTION** recently. He also blamed traffic density for sludge formation — because traffic congestion causes low-duty operation.

SUPPLY REQUIREMENTS of space vehicles was the subject of **NORTHERN CALIFORNIA's SOUTH BAY DIVISION's** meeting at which Dr. Donald T. Perkins was the guest speaker. Perkins, scientific advisor for Spacecraft, Lockheed California Co., said that lunar expeditions are possible with present boosters and propulsion systems. Since 3430 lb of supplies per month would be needed to maintain a six man space station in an earth orbit, space operations become a problem in logistics. The stages in space must be utilized at maximum efficiency.

Happy Anniversary

FIFTY YEARS OF GROWTH in the automotive industry have been accompanied and aided by **METROPOLITAN, PHILADELPHIA,** and **DETROIT SECTIONS,** who have been celebrating their 50th birthday during 1961. These Sections started in 1911.

In 1911, 32 out of a total 53 SAE members living in the vicinity of Philadelphia decided to join the Section, feeling "that the usefulness of the Society will be materially advanced through the formation of local branches." The Section, which proved to be correct in its "feeling," was chairmaned by Henry Hess, a past-president of the Society, who had served in 1909.

In 1911, SAE already had to contend with "too many papers." The minutes of **METROPOLITAN SECTION** meeting of April 27, read ". . . that no new papers should be presented until after the papers already presented at the Society meetings for the year 1910 and thereafter shall have been digested and discussed." William P. Kennedy, who received his 50 year membership certificate six years ago, was chairman of Metropolitan Section at its inception.

In 1911, **DETROIT SECTION** Chairman E. T. Birdsall, who had been the first secretary of SAE, explained that "a small gold "D" pendant attached to the SAE emblem would be the symbol of the Detroit Section," and that arrangements had been made to attach these "D's" for 80 cents. The Section included Flint, Jackson, Saginaw, Lansing, Bay City, and Toledo members, and intended to arrive at "a suitable descriptive name."

CINCINNATI SECTION GOVERNING BOARD, 1961–62. Front row, left to right: J. D. Bourke, vice-chairman and representative to T.S.S.C. Council; E. J. Schmerber, secretary; E. P. Waldman, chairman; J. F. Dooley, membership chairman; E. Lohaus, treasurer.

Back row: W. A. Kimsey, Journal field editor; E. J. Raut, meetings chairman; O. L. Negangard, arrangements chairman; T. J. McGucken, membership co-chairman; F. W. Biederman, Journal co-field editor; J. T. Volle, publicity chairman; E. H. Pitzer, picnic committee chairman; A. Komisar, arrangements vice-chairman; J. A. Scheiber, alternate representative to T.S.S.C. Council.

"PRESIDENTS' NIGHT" WAS WESTERN MICHIGAN SECTION's meeting at which SAE President Dr. A. A. Kucher was guest speaker. Top level executives were present from companies in the Western Michigan area. Dr. Kucher showed a color film taken during his recent visit to Europe. (Left to right) Dr. A. A. Kucher, SAE president; A. H. Frauenthal, chairman of the board, Kaydon Engineering Corp.; Paul F. Bergmann, president, Johnson Products, Inc.; Donald M. Hesling, vice-president, Research and Engineering, Sealed Power Corp.

INDIANA SECTION speaker K. A. Stonex, G. M. Proving Ground, (center) is congratulated by Section meetings chairman, M. E. Fisher, GMC (left) and Section Chairman R. M. Tuck, GMC.

SPOKANE-INTERMOUNTAIN SECTION INSTALLATION OF OFFICERS

Rambling through Governing Board Minutes

NEWSPAPER COVERAGE is mentioned by **WESTERN MICHIGAN** and **ATLANTA SECTIONS**. . . . Western Michigan is interested in extending its coverage to new areas, Atlanta is arranging for monthly publicity in "Automotive News." . . . A current list of members and their addresses is being made available to Atlanta Section membership, after removing the names of those people who have become inactive. These names are to be divided among Governing Board members for personal contact to renew activity and interest. . . . **MONTREAL SECTION** organized a telephone committee, which was functioning in time for their first meeting this year, to aid reception and attendance. . . . British Engineering Institute has been informed that they are welcome at Montreal Section meetings. . . . Lapel pins are being presented to new members of **SOUTHERN NEW ENGLAND SECTION** . . . new members do not include transfer members from other Sections. **CHICAGO SECTION** finds that diesel engine meetings have attracted the largest attendance. . . . Prepared questions or discussions were suggested to stimulate question-and-answer periods . . . also, "no table reservation" dinners are being inaugurated to facilitate "mixing" among the engineers. . . . **WESTERN MICHIGAN SECTION** is planning a Past-Chairman Night — at which all past-chairmen will be invited guests, including transfer members of the Section who were chairman of other Sections.

NORTHWEST SECTION and **SALT LAKE GROUP** are both planning to participate in this season's Pacific Coast Guest Speaker Round Robin. . . . Round Robin works this way: each West Coast, Northwest, and Intermountain Section and Group submits a list of desired speakers to C. A. Dillinger, Northwest Area Coordinator. At a central meeting, Round Robin speakers are selected from those being requested most often by the participating Sections and Groups. . . .

FORT WAYNE SECTION is underwriting Engineer's Week. Purdue Extension, Indiana Tech, and Tri-State each receive a technical book from each participating society . . . to be displayed at Engineer's Week Banquet. . . . Greater student attendance at technical meetings is anticipated by **SOUTHERN NEW ENGLAND SECTION**, which is considering offering support with speakers and/or prizes to Science Clubs and Science Fairs. An annual Science Fair is held by Connecticut Valley colleges where this type of sponsorship might be appropriate. . . . **NORTHWEST SECTION** also wants to pay more attention to students for higher attendance. Chairman Brown sent a letter to the Student Chairman of SAE's Student Branch at University of Washington, telling of the Section's interest in student affairs. To introduce students to local men from industries, a board member will attend student meetings. An effort will be made to acquaint students with local companies.

SAE Section Meetings

ATLANTA

December 4 . . . E. B. Gibson Jr., chief advanced design engineer, & J. F. Sutton, chief technical assistant. Lockheed-Georgia Co. "The Lockheed Hummingbird Program." Yohannan's Restaurant. Social half hour 6:30; dinner 7:00; meeting 8:00.

CHICAGO

December 12 . . . Arthur H. Pedersen Sr., laboratory project engineer. McDonnell Aircraft Corp. "Project Mercury-Test Development Background." Knickerbocker Hotel. Social half hour 6:15; dinner 6:45; meeting 8:00.

COLORADO

December 6 . . . John C. Campbell, field relations. Detroit Diesel. "Causes of Power Loss & Late Trends." GMC Training Center, Denver, Colorado. Dinner 6:30; meeting 7:30.

FORT WAYNE

December 13 . . . Marlin Miller, value analysis supervisor. International Harvester Co. "Value Analysis." Colonial Restaurant, Fort Wayne, Ind. Dinner 7:00; meeting 8:00.

MID-CONTINENT

December 1 . . . General Motors Truck & Coach Div., GMC. Transportation & Maintenance Meeting. Tour of General Motors Training Center, Oklahoma City, Okla. Social hour 6:00; dinner 7:00; meeting 8:00.

METROPOLITAN

December 7 . . . Robert L. Seat, sr. group engineer. McDonnell Aircraft Corp. "Project Mercury." Brass Rail Restaurant, Fifth Avenue between 43 & 44 Streets, Manhattan. Social hour 5:30; dinner 6:30; meeting 7:45.

MILWAUKEE

December 1 . . . Dr. D. D. Kececioglu, director of reliability. Allis Chalmers Mfg. Co. "Panorama of New Power Generation Developments." Milwaukee Athletic Club. Dinner 6:30; meeting 8:00.

MONTREAL

December 13 . . . Ladies Night-Dinner-Dance. Sheraton Mt. Royal Hotel, Peel St., Montreal.

PHILADELPHIA

December 13 . . . Aerospace Meeting. Coffee speaker, Chilton Industries.

INDIANA

December 14 . . . Representatives from Warner Gear & Allison Div., GMC. "Panel Presentation on Automatic Transmissions." Continental Hotel, Indianapolis, Ind. Dinner 7:00; meeting 8:00.

TEXAS GULF COAST

December 13 . . . R. G. LeTourneau, V. P. Chg. Prod., R. G. LeTourneau, Inc. "Research Development & Production of Large Earth Moving Equipment." Houston Engineering & Scientific Society. Social half hour 6:00; dinner 6:30; meeting 7:45.

SOUTH BAY

December 5 . . . Robert D. Gilson, project engineer. Lockheed Georgia Co. "Development & Design of the Lockheed C-141A Cargo Transport Aircraft." Old Plantation, El Camino & San Antonio Road, Los Altos. Social hour 6:30; dinner 7:00; meeting 8:00.

JET AIRCRAFT NOISE measurement improvement is the overall task of a new SAE group meeting here for the first time under the chairmanship of Frank Kolk (at head of table — white shirt), American Airlines. The group is seeking a uniform method of data recording, data reduction, and presentation as well as more uniform instrumentation techniques. The Jet Aircraft Noise Committee is part of SAE's Aerospace Council.

STOPPING A JET TRANSPORT in 1240 ft from 111 knots without thrust reverser or brakes was one of the facts reported at the Air Transport Activity Committee meeting run by Chairman John Lowry (5th from left). These stops resulted when a Boeing 720 was equipped with a leaf spring hook and a U. S. Navy ground type arresting gear was installed on the runway. These feasibility studies also suggest a beneficial side effect of holding the plane in a straight configuration during landing.

Also reported was the fact that fuel filters are a major source of electrostatic charge during pumping operations. The charge will dissipate with time, however in present commercial installations sufficient time is usually not available.

1962 SAE PRESIDENTIAL NOMINEE Frank Fink presents plaque for outstanding service to Alex Burton (right) in appreciation of his job as general chairman of the Meeting.

NELS SHAPPELL, chairman of the 1962 Manufacturing Forum (right) and Robert Clark, (center) present chairman, talk over the results of this year's forum with Mr. Rice, who represented B. F. Raynes, sponsor of the Manufacturing Forum.

EXECUTIVE COMMITTEE members of the Manufacturing Forum are already setting up plans for next year based on results of the present forum. Projecting the manufacturing techniques necessary to build missiles 5 to 10 years from now was one of the items discussed.

Forecast landing mishaps down 80% with

new automatic landing systems

at SAE National Aeronautic and Space Engineering and Manufacturing Meeting

SPACE VEHICLES, transports, turbine and rocket engines, materials, manufacturing techniques, reliability, and value analysis are just some of the technical subjects analyzed at the 1961 National Aeronautic and Space Engineering and Manufacturing Company.

Completely automatic landing systems were presented by Vickers for possible introduction in 1963. The dual system would not need pilot assistance in case of a component failure. It's expected that such a system would reduce landing accidents of jets to 1/5th of their present rate as well as improve the scheduling efficiency of aircraft.

Supersonic transports may not stop at Mach 3 according to a study report on a Mach 7 transport designed to link the major cities of the world in two hours.

For the Mach 3 transport, a 10-point program was offered at the meeting. It included: start using supersonic equipment on existing jets wherever possible; project recently obtained jet operation experience to supersonic operational problems; design the supersonic transport conservatively; start terminal construction; correct present equipment problems as a step to eliminating similar future problems with supersonic jets; make simulator studies of equipment and aircraft; conduct financial analysis to insure that the supersonic transport will be profitable as a primary, not a special means of transportation; maintain aircraft designer manpower until hardware is ready to be built; anticipate the changes in route system that will be necessary; use the proven check and balance system between airlines and manufacturers in the development and test stages of a supersonic transport program.

Reliability is taking on a cradle-to-grave emphasis as prime contractors put their own house in order and look to give help to vendors, operators, and maintenance people. Part of the emphasis is really evaluating the reliability of normal people . . . since instructions aren't always followed even when understood and communication between people is hardly an exact science. For example, two close-by plug-in connections may have a high mechanical reliability, but if they are identical the probability of human error quickly degrades the final reliability.

New manufacturing techniques described include the use of selective tempering of materials to speed later machining operations, computer controlled drilling that increases tool life by a factor of 20, adding a short-lived radioactive tracer to welding rod as a means of weld inspection, and butt welding sheets as thin as 0.001 in.

Earth men may explore the moon in over-sized space suits which will be attached to a four-wheel supply cart by umbilical cables, was a space travel analysis presented. The power system might well be a hydrogen-oxygen fuel cell. Two men could be attached to each supply cart and disconnect themselves at will for short exploratory walks, during a ten-day stay in the suit. The large hard-shell suit would permit men to use their hands inside the suit for control and bodily functions.

Value analysis was brought out as a tool that is as important to management decisions as a good reliability program is to the performance of the product. Teams of experts approach a product proposal from the standpoint of producing the *function* required at the lowest cost. One of the main operations of value analysis is finding alternate ways to perform the function and then evaluating all costs as a basis of comparison.

The use of detonation combustion may be a way of increasing the efficiency of ramjet engines. Detonation flame speeds can be several orders of magnitude faster than normal flame propagation and this effect has already been demonstrated for a stationary flame and a moving gas. This would mean that air would not have to be decelerated to subsonic speeds for combustion. The immediate result of high speed burning by combustion detonation would be: lower component temperatures, lighter and more efficient inlet and exhaust nozzles (there would be no contraction section in the exhaust nozzle), and less thermal dissociation. These factors could extend the efficiency of a hypersonic ramjet close to the values usually found for supersonic operation.

SAE National Aeronautic and Space Engineering and Manufacturing Meeting

. . . continued

1. FUTURE REQUIREMENTS . . .

3. MAJ KLEIN . . .

4. WRIGHT BROTHERS . . .

1. FUTURE REQUIREMENTS . . .

. . . for powerplants discussed by the members of the Aerospace Powerplant Activity Committee included hydrogen engines and fuels for supersonic transports.

The drop in component temperature experience by using liquid hydrogen as a fuel for space vehicles means that the techniques already developed for liquid oxygen must be improved. Components satisfactory for oxygen often will have to be redesigned for liquid hydrogen applications. Also, problems arise in restarting hydrogen engines after they have been orbiting for days and components are essentially at the temperature of the liquid hydrogen.

New fuels for Mach 3 transports may be in the offing to replace kerosene. Such fuels would burn clean and have high chemical stability without the use of additives . . . giving the aircraft designer more flexibility than presently possible with kerosene.

Dale Streid, chairman of the committee (3rd from left) led the meeting after the informal discussion shown here.

2. VISITING . . .

. . . the meeting was Bryan R. Noton, D.C.Ae, who is the technical assistant to the director of the Aeronautical Research Institute of Sweden and also a consulting engineer.

After listening to and participating in the discussions at the manufacturing forums, Noton (shown here looking over some of the papers given at the meeting) commented that a unique and most valuable aspect of the meeting was the free interchange of ideas, research results, and views on problems encountered by competitors in the aerospace industries.

He felt that the forum discussions accentuated this interchange of information to a degree not found in symposiums and conferences held elsewhere. Also he said the numerous forums indicated that over a short period, the American aerospace industry has evolved such sophisticated materials and structures, and such new design concepts as composite configurations, that one should always take these achievements into account when comparing progress and status with foreign powers, and not just consider the thrust of rockets as is often done.

Noton participated in the forum on Foreign Manufacturing Techniques and presented a paper on the applications of bonded and brazed honeycomb sandwich construction in Europe. These applications covered the use of

2. VISITING . . .

B. F. RAYNES, senior vice president, Rohr Aircraft Corp. 1961 Sponsor, SAE National Aeronautic & Space Manufacturing Forum.

S. K. HOFFMAN, president, North American Aviation, Rocketdyne Division. 1962 Sponsor, SAE National Aeronautic & Space Manufacturing Forum.

5. GENERAL . . .

6. LANDING AN 880 . . .

a variety of plastic and metallic material combinations for gliders, sport and civil aircraft, and missiles. He particularly pointed out developments of low-cost core materials in Europe that will have a tremendous impact on the introduction of composites in other automotive industries . . . where materials developed for aerospace vehicles present an "economic barrier."

3. MAJ KLEIN . . .

. . . (back to camera) of Douglas spellbinds the fellows with one of his stories.

4. WRIGHT BROTHERS . . .

. . . **AWARD WINNER** Ferdinand B. Greatrex (left) accepts award from E. H. Heinemann, chairman, Wright Brothers Board of Award.

Greatrex was awarded SAE's 1960 Wright Brothers Medal for his paper "By-Pass Engine Noise," presented at the SAE Aeronautical Meeting in New York in April, 1960. Greatrex is assistant chief engineer of Rolls Royce, Ltd.

The Wright Brothers Medal is awarded annually to the author of the best paper on aerodynamics or structural theory or research, or airplane design or construction, which was presented at a meeting of the Society or any of its Sections during the calendar year.

5. GENERAL . . .

. . . **chairman of the Manufacturing Forum** Bob Clark (right) receives plaque for outstanding service from 1962 SAE Presidential Nominee Frank Fink.

6. LANDING AN 880 . . .

. . . at 160 knots in 1½ in. of slush showed only a dimpling of the trailing edge of the wing, recent tests revealed. This was one of the items reported at the Aerospace Activity Committee meeting headed by Harold Zipp, Boeing (at head of table). One problem resulting from running the tests was a depletion of the ice supply in the surrounding neighborhood, since a layer of chopped ice 3000 ft long and 50 ft wide was needed.

SAE National Aeronautic and Space Engineering and Manufacturing Meeting

. . . continued

1. DISCUSSING MEETING PLANS . . .

3. ALEX BURTON . . .

4. STUDENT CHAIRMAN . . .

1. DISCUSSING MEETING PLANS . . .

. . . **MEETING PLANS** are: (l-r) A. T. Burton, F. B. Tipton, H. E. Herdrich, and R. L. Clark. Burton was general chairman of the Meeting and Clark was general chairman of the Manufacturing Forum. Tipton is chairman of SAE San Diego Section and Herdrich is chairman of SAE Southern California Section. The two Sections acted as host to the Meeting.

2. STUDENT NIGHT . . .

. . . **PRESENTED AN OPPORTUNITY** for Southern California Section officers to meet outstanding faculty members from Southern California schools. Participating from SAE Southern California Section were P. L. Garver, student chairman; Gil Way, vice chairman; Rudy Polak, secretary; John Barnes, Aero-Space Activity vice chairman; Bill Page, assistant Aero-Space Activity vice chairman & Aero-Space Panels; Ed Whitney, membership chairman;and John Longenecker, Continental Sales & Service Co., who was a guest at the meeting.

Faculty members attending the meeting were: Prof. Maury Kramer, Northrop Institute of Technology; Dr. Dino A. Morelli, California Institute of Technology; Dr. Harold Skamser and Prof. Harvey A. Mylander, California State Poly — Pomona; Richard Kombrink, California State Poly — SLO; Joseph P. Callinan, Loyola University; Dr. Alfred C. Ingersoll and Prof. C. R. Freberg, University of Southern California; Prof. W. Julian King, University of California at L. A.; Joseph D. Thompson, Art Center School; Dr. Warren E. Wilson, Harvey Mudd College; and Dr. C. V. Metzler, San Fernando Valley State College.

3. ALEX BURTON . . .

. . . makes a point to Mel Smith, chairman of the Northrop student section (left) and Joseph Gilbert, SAE general manager (center), just before the start of the student program.

2. STUDENT NIGHT . . .

5. WRAPPING UP . . .

4. STUDENT CHAIRMAN . . .

P. L. Garver (far right) talks to students attending the special student program held as part of the SAE National Aeronautic and Space Engineering and Manufacturing Meeting. The two themes developed by a panel of experts were: The young engineers' attitudes and expectations in the aerospace industry, and a scientific projection of future technical fields necessary to accomplish a space mission.

The speakers on the program were: J. B. Wassall, Lockheed Aircraft Corp., chairman; Edward Wells, Boeing Co., keynote speaker; Edward R. van Driest, North American Aviation, Inc.; William F. Ballhaus, Northrop Corp.; and John Stack, NASA.

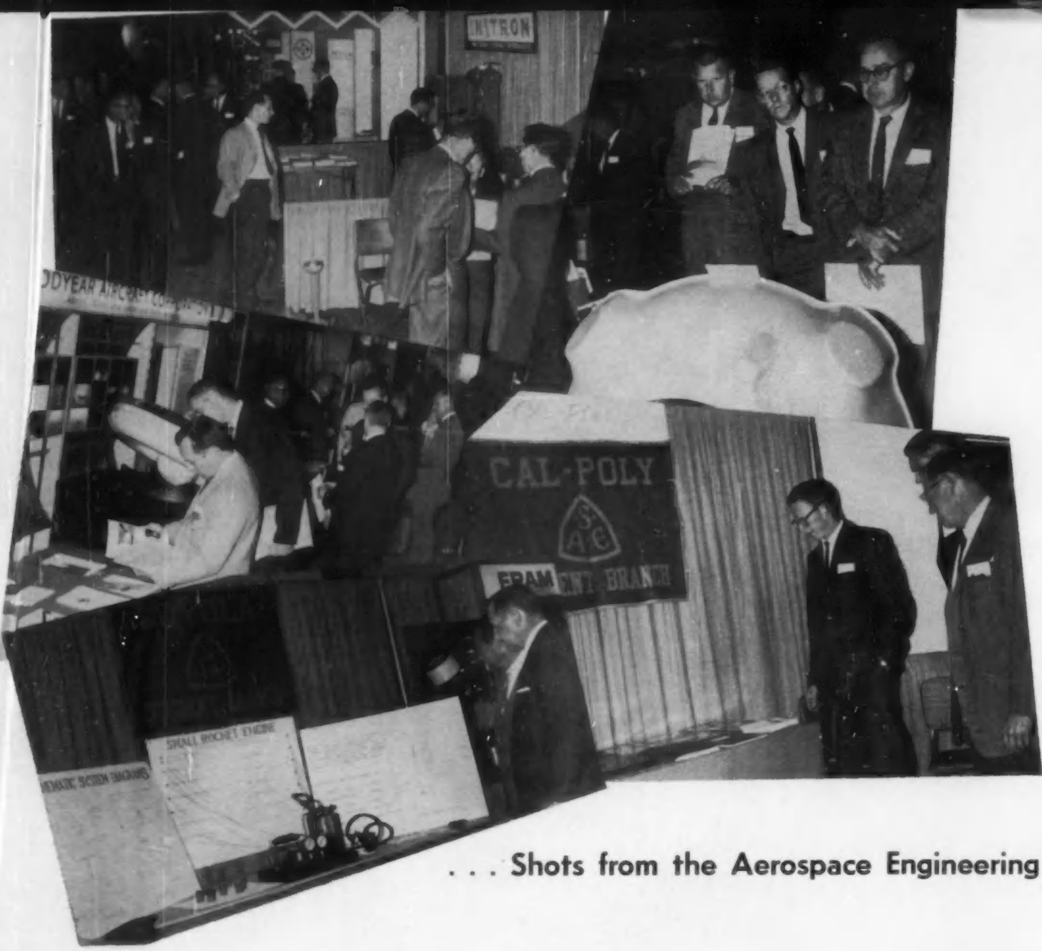
5. WRAPPING UP . . .

. . . a designer's manual on Reliability and starting cooperative work on two new potential projects was the result of the meeting of the Right Approach to Reliability Subcommittee. The eight basic sections of the manual will be drawn into an integrated book by a special editing team in the next couple of months. The book will then be published in the new SAE Technical Progress Series.

The gathering of failure rate data on specific components will continue until there is sufficient quantity and agreement on the best form of presentation. Then the information will be issued as a supplement to the manual. Presently the manual will contain sections on: Design Reliability Creation Processes, Design Reliability Assurance and Monitoring Practices, Reliability Assurance Testing, Vendor Controls, Data Feedback Systems, Program Management, Mathematical Concepts, and Glossary.

New work considered at the meeting was a program on the standardization of the parameters upon which vehicle reliability is based. It was felt that there may be confusion and contractual inequities resulting through the use of nonstandard language. Also, new manuals on the effect of manufacturing and maintenance on reliability may be developed to supplement the present designer-oriented manual.

R. E. Ledbetter, General Electric Co. (4th from right) led the meeting as the new chairman, replacing F. D. Applegate, General Dynamics Astronautics (5th from right), who retired as chairman because of new company responsibilities.



... Shots from the Aerospace Engineering Display

... Views from the Manufacturing Forums

SAE MEMBERS

Raviolo

VICTOR G. RAVIOLO has been appointed director of engineering for Ford Motor Co., Ltd., Dagenham, England. He has been Ford's executive director of engineering, Engineering and Research Staff, Dearborn.

Raviolo has been with the Ford organization since 1940 and moved to his present position through a series of executive engineering posts. He has served SAE in many important technical and administrative committees. He has been an active member of both the SAE Engineering Activity Board and the SAE Technical Board. As chairman of EAB's Publication Advisory Committee for the last two years, he has stimulated current movement toward better coordination and communications between all SAE groups concerned with publications. He has also made major contributions to Coordinating Research Council activities.

Roskam

DELBERT L. ROSKAM, former vice-president of Cessna Aircraft Co.'s aircraft divisions, has recently been elected senior vice-president of the company. He will monitor and advise engineering, manufacturing and marketing functions in all of the company's operating divisions and subsidiaries.

Teree

B. R. TEREE, chairman of SAE's Aerospace Hydraulic and Pneumatic Systems and Equipment Committee, has joined Weston Hydraulics, Ltd., as market development manager. He will be responsible for the market research and development programs of both the aerospace and the new industrial divisions of Weston.

Taylor

PHILIP B. TAYLOR, formerly Assistant Secretary of the Air Force (for Materiel), has been elected to the Board of Directors of General Precision Equipment Corp. Prior to his assistant secretaryship, which he held from 1959–61, Taylor was a management consultant specializing in the engineering and construction fields.

JEAN C. PAOLUCCI, formerly maintenance engineer with the Montreal Transportation Commission, is now engineering representative for Francon, Ltd., manufacturers of prestressed concrete.

DR. STEPHEN KALMAR has been appointed director of industrial relations of the Lawrence Institute of Technology. In addition to his industrial assignments, Kalmar will have faculty assignments, conducting seminars for senior students and alumni. Upon his retirement from General Motors Corp. this summer, he was executive assistant engineer in charge of power development for the GM engineering staff.

STERLING J. SPLEET, formerly manager of sales and technical service motors for American Oil Co., is now in charge of marketing technical service at the company's general office in Chicago. He has been with the company since 1936.

R. C. MOUAT, instructor in charge of the motor section at John Orr Technical High School in Johannesburg, South Africa, will also be acting vice-principal of the school for the last six months of this year.

ROBERT L. MENTZER is analytical engineer with Pratt & Whitney Aircraft. Prior to this position, he was an engineer and graduate student at Chrysler Corp.

WALTER F. VELGOT, JR. 25 year aviation engineer is now senior application engineer for Lockheed Aircraft Service, Special Devices Division. He was previously with Curtiss-Wright Corp.

DONALD H. THOMAS is working at Case Institute of Technology as a graduate assistant, doing research in the field of medical engineering. He was previously assistant professor of mechanical engineering at Drexel Instatute of Technology. Thomas was Faculty Advisor of the SAE Student Branch at Drexel for the 1960–61 school year.

JOHN R. STONE received honorable mention certificate from the American Society of Safety Engineers for his paper "Making Safety a Part of Doing Business." Stone is safety director of Oldsmobile Division, General Motors Corp, and has been associated with the company since 1930.

VICTOR HOLT, JR., executive vice-president of Goodyear Tire & Rubber Co., was elected chairman of the Board of Directors of the Auto Industries Highway Safety Committee. Holt said that the committee would continue to develop and conduct highway and traffic safety activities supporting the "Action Program" of the President's Committee for Traffic Safety.

JOHN A. PANKHURST is now sales engineer for Truscotts, Ltd., in New Zealand. He had been sales engineer for Cartex Oil, Ltd., prior to his new position.

DONALD M. WALTZ has joined the Boeing Co. as associate tool engineer. Formerly, he was junior layout man at Chevrolet engineering.

EDMUND C. DECKER, JR., previously quality control engineer for the General Electric Co. in Ohio, has moved to the Vermont plant of the company.

JON E. MILLER holds the position of senior engineer at the Martin Co., where he is technical coordinator for non-destructive testing division.

HOWARD C. BEYER has been elected President of Jeta, Inc. He was formerly manager of the Power Equipment Division of the company, which manufactures engine generating plants for U.S. Government military requirements.

Mason

McMullen

W. HORACE MASON, president of Seiberling Rubber Co. of Canada, Ltd., has been appointed vice-president and treasurer of the parent Seiberling organization in Akron.

A. L. McMULLEN, formerly vice-president in charge of production, assumes the general operating duties of Mason. McMullen has been elected vice-president and general manager of the company in Canada.

W. H. LOVE has been appointed national field service manager for Dodge Car & Truck Division, Chrysler Corp. He has been with the company since 1952, and has been regional service manager for the Cincinnati region since 1957.

TERRANCE M. HERBERT has completed his first year as a trainee in General Electric Manufacturing training program. He is now in his second year, and works as a mechanical engineer.

JAMES E. RISSMAN has recently become associated with Magna Products, Inc., as technical liaison manager, Research and Development Division.

WALTER R. MacKENZIE has been selected as manager of a new technical projects department of the Chevrolet sales department. Associated with Chevrolet engineering for the past 32 years, Mackenzie's new assignment makes him responsible for integrating a greater emphasis on the technical aspects of the company's products into the over all merchandising approach.

FRANK R. SWANEY, JR. has been named director, operations, Aircraft-Missiles Division of Fairchild Stratos Corp. A twenty year man with Chrysler Corp., Swaney was one of the original team that started Chrysler's Missile Division.

ALEX C. MAIR has been made assistant chief engineer in charge of truck body and chassis design of the Chevrolet Motor Division of GMC. He has been a member of the Chevrolet engineering organization since his graduation from General Motors Institute in 1943.

J. H. ROBBLEE was elected vice-president of the National Wheel and Rim Association for 1961–62 at the 38th annual convention of the Association.

GEORGE M. BUNKER, Chairman of the Board of the Martin Co., is president and chief executive officer of the newly formed Martin-American Corp. The consolidation of the Martin Co. and the American-Marietta Co. was recently approved by the stockholders.

Beyer

MacKenzie

Bunker

Nepon

Gilliam

Blomquist

GERALD D. NEPON, formerly regional sales manager, national accounts, has been made assistant to the President of the Berman Leasing Co. He has been with the company for the past nine years.

GEORGE M. McNULTY, of the Humble Oil and Refining Co., has recently become coordinator, sales service laboratory. His old position was that of manufacturing coordinator.

RICHARD P. COVER, has recently become methods engineer for the Chevrolet Division of General Motors Corp.

Gjerde

M. D. GJERDE, after more than 36 years service, retired November 1 from American Oil Co., affiliate of Standard Oil Co. (Indiana). For the last 24 years, Gjerde has been in charge of marketing technical service. Earlier he was head of the automotive division in the sales technical department. He is a graduate of Purdue with a Bachelor of Science degree in mechanical engineering, and worked for American Manganese Steel Co. and for Bowser, Inc. before joining Standard Oil (Indiana). For many years, he has played an active and leading part in SAE technical committee work and served for several years as chairman of the SAE Fuels & Lubricants Technical Committee.

JACK L. GILLIAM has been named director of purchasing for the electronics operation of Avco's Electronics and Ordnance Division. He joined the company a year ago as a marketing representative.

Ginman

ORLO J. BLOMQUIST has become powerplant engineer for the U.S. Corps of Engineers.

W. K. GINMAN has been appointed sales manager of the Induction Heating Equipment Division, National Automatic Tool Co., Inc. For the past 14 years, Ginman was Detroit district manager for the Tocco Division, Ohio Crankshaft Co.

Newton

GAYLORD W. NEWTON has accepted a new position with General Electric Co. in Cincinnati. Formerly in the aircraft nuclear propulsion department, Newton is now in the marketing operation of the large jet engine department.

Asch

NEWEL W. JOHNSON has joined the Wyle Laboratories as test engineer.

EDWARD L. ASCH has been appointed operations manager, International Division of Vickers, Inc., Division of Sperry Rand Corp. **DANE E. SMITH** replaces him as director of sales training for Vickers.

An engineering graduate of M.I.T., Asch has been with Vickers for over 20 years. He will supervise the personnel, engineering, production, marketing activities, and export operations of the International Division.

Smith, district sales manager in St. Louis prior to his present position, has been with Vickers for eight years.

Smith

JULIUS E. WITZKY has joined the staff of the department of automotive research at Southwest Research Institute as a senior research engineer, working on many phases of diesel engine study. He received his diploma in engineering from the Polytechnikum, Stuttgart, Germany, and came to the United States in 1945 under a special program providing for entry of prominent foreign scientists.

Witzky

SAE Father and Son

WILLIAM J. ZECHEL, chief design engineer for American Motors Corp., whose son Gary is an SAE Enrolled Student. **GARY ZECHEL** (right) will be graduated from the Dearborn Center of the University of Michigan in 1962 with a B.S. degree in mechanical engineering.

COLONEL CARL C. SAAL, Chief of the Traffic Operations Division, U.S. Bureau of Public Roads, has been appointed Commanding General of the 435th Transportation Highway Transport Command (Reserve) in Washington, D. C.

After a four month training program, he will qualify for the rank of Brigadier General. Saal is an active member of the SAE Technical Board's Brake Committee.

DONALD D. FERM, previously research engineer with King-Seeley Thermos, is now development engineer with CTS Corp. The company manufactures electrical components.

PAUL E. JAQUISH, JR. is now senior research engineer for the Defense Systems Division, General Motors Corp. He was formerly project engineer, Saginaw Steering Gear.

EUGENE C. COAN, previously mechanical assistant for the Great Northern Railroad, has now become master mechanic, responsible for enginemen and mechanical forces operating on the Butte Division.

D. C. ROWE has been named manager of manufacturing research and development of Vertol Division, Boeing Airplane Co.

BERNARD R. HEYMANN has been appointed chief engineer of aircraft manufacturing facilities for the Van Nuys, Calif. plant of Purolator Products, Inc. A mechanical engineer who received his education in Germany and Switzerland, Heymann has been involved with the design and manufacture of aircraft and missile valves in his previous positions.

JOHN B. WHITE becomes general manager of window glass plants for Pittsburgh Plate Glass Co., as of Jan. 1, 1962. Currently attending the advanced management training program at Harvard University, White joined Pittsburgh Plate in 1952 as an industrial engineer.

FRED HALL has joined the Pearson Corp., as sales manager of the Grumman Division. He will handle aluminum boats and canoes, and fiberglass boats 21 feet or under.

DANIEL Q. MARSHALL has recently become manager, mechanical design, Pratt & Whitney Co., Inc. Marshall has been a member of the SAE's Power Plant Activities Committee under the EAB.

COLIN CAMPBELL, formerly associated with Purolator Products in various capacities, has become manager, Canadian area, Meter & Service Station Equipment Division, A. O. Smith Corp. Campbell is the author of several papers on the subject of aviation refueling.

LOUIS F. POLK, Chairman of the Board of the Sheffield Corp. and vice-president and group executive of the Bendix Corp., received the American Standards Association's 1961 Howard Coonley Medal.

Polk was honored for his record of achievements which are "indicative of the service he has rendered since 1932 to the advancement of standardization and the understanding of its unquestioned role in the American economy."

ALBERT W. JORDAN has been appointed chief engineer of the Climax Engine Mfg. Co., a division of Waukesha Motor Co. He has been with the Climax Division since 1959. In his new assignment, Jordan supervises all engineering and experimental activities of the plant.

J. J. BIGELOW has joined Hayes Industries, Inc., as sales manager of the Jet-Flo Muffler Division. He has been associated with the automobile accessories industry for over 40 years.

WILLIAM A. McCONNELL, of Ford Motor Co., has recently accepted a new job and title. He is now manager, performance analysis department, Technical Analysis Office, engineering staff.

McConnell is assistant vice-chairman for the SAE's Passenger Car Activity under the EAB, and has held many assignments on the Detroit Section Governing Board.

JACK F. WITTEN, former head of the maintenance engineering research unit of the Weapons Engineering Division, Bureau of Naval Weapons, has been named assistant head of the maintenance programs branch, Weapons Engineering Division.

Chapman

RICHARD D. CHAPMAN has been named to head up the copper-mill industry's office in Detroit, it has been announced by the Copper & Brass Research Association. Chapman will aim to acclerate technical liaison between leading makers of wrought-copper products and the automotive industry. Until recently assistant chief engineer of Chrysler's Basic Sciences Research, Chapman's experience has spanned a wide range of metallurgical research, pioneer studies in X-ray diffraction, metallographic investigations and dilatometric studies. He holds engineering degrees from both Michigan State University and Chrysler Institute of Engineering.

Ingersoll

ROY C. INGERSOLL, 76, has retired as chairman of the board of Borg-Warner Corp. An official of the company for almost as long as it has been in existence, Ingersoll was named to the newly created position of honorary chairman. His resignation brought to a close an active career of more than 53 years.

WALTER T. BURWELL has been appointed assistant chief engineer in charge of specialized products at Chevrolet Motor Division, GMC. The position, which has just been created, includes design responsibilities for all fleet vehicles, specifically those for government and military use. Burwell has been with Chevrolet since 1941 when he joined the company's aviation division as a project engineer.

L. S. HOLLINS was elected chairman of the board, and **J. DAVID MARKS** was elected executive vice-president of Signal-Stat. Hollins, who had been president of the firm, now plans to devote more time to highway safety matters. Marks, prior to his present position, had served the company in an advisory capacity.

H. F. DAVIS, Champion Spark Plug Co., and **T. A. KREUSER**, Bendix Automotive Service, Bendix Corp., have been elected directors of the Motor and Equipment Manufacturers Association for the 1962–63–64 term.

W. A. RAFTERY of the Signal-Stat Corp. is one of the MEMA board of directors for 1962.

RUSSELL L. GILPIN has recently been appointed to the position of sales manager of the Universal Joint Division of Dana Corp. He joined Dana in 1954 as a sales engineer, handling accounts in the various divisions of General Motors and Willys.

Gilpin

RICHARD M. POWERS has become test engineer for American Machine & Foundry, manufacturers of launcher equipment. He was formerly special tester, Cadillac Motor Car Division, GMC.

RAYMOND P. LANSING, vice-president of Bendix Corp., has been named by the New Jersey Wing of the Air Force Association to receive its 1961 Air Power Trophy. The award honors Lansing for "outstanding contributions to aviation and as a leader in the aviation-electronics-aerospace industry during a career spanning 46 years."

ROBERT SCHILLING has retired after 34 years of service with various General Motors Divisions. His most recent position was with Adam Opel A.G. in Germany. He and his wife plan to live in the Southwest.

Obituaries

HUGH DEAN . . . (A'29) . . . retired, formerly vice-president in charge of manufacturing staff, GMC . . . died September 3 . . . born 1887.

LAWRENCE P. FISHER . . . (M'26) vice-president, Fisher & Co. . . . died September 3 . . . born 1889.

WILBERT C. FREER . . . (A'57) . . . salesman, Diesel Service Unit Co. . . . died July 10 . . . born 1919.

A. S. ORR . . . (M'46) . . . director, product quality manufacturing department, Gulf Oil Corp. . . . died August 6 . . . born 1903.

LEON B. ROSSEAU . . . (M'55) . . . president, Ajax Electric Co. . . . died September 15 . . . born 1898.

JOHN W. WATSON . . . (M'14) . . . president, John Warren Watson Co. . . . died September 8 . . . born 1882.

CHARLES E. WILSON . . . (M'14) . . . retired, formerly Secretary of Defense, U.S. Government; president, GMC . . . died September 26 . . . born 1890.

NATHAN WEINGARDEN . . . (M'29) . . . chief chassis draftsman, Pontiac Motor Division, GMC . . . died October 24 . . . born 1902.

Among SAE Enrolled Students
who have entered industry

MUREL G. BROWN . . . Northrop Institute of Technology . . . test lab technician, McCulloch Corp.

GEORGE BUGARIN . . . University of Detroit . . . general engineer, U. S. Army Ordnance Arsenal, Detroit.

DONALD M. DAVIS . . . Pennsylvania Military College . . . jr. engineer, Firestone Plastics Co.

ROBERT S. HARRIS . . . General Motors Institute . . . designer, Chevrolet Motor Division, GMC.

PAUL W. ING . . . University of Wisconsin . . . staff engineer, IBM General Products Laboratory.

WILLIAM G. IRVINE . . . University of Saskatchewan . . . assistant resident engineer, Department of Public Works, Government of Canada.

KARL G. LUNDIN . . . University of Toronto . . . technical sales engineer, Reliance Electric & Engineering, Ltd., Toronto, Canada.

ROLAND K. REYNOLDS . . . A&M College of Texas . . . engineer in training, Standard Oil Co. of California.

HARVEY SIEGEL . . . University of Toronto . . . mechanical engineer, Texaco, Inc.

DAVID J. VAN BLOIS . . . Lawrence Institute of Technology . . . associate engineer, Whirlpool Corp.

JOHN S. WARD . . . California State Polytechnic College . . . mechanical engineer, U.S. Naval Ordnance Test Station, China Lake, Calif.

SAE ENROLLED STUDENTS AT MADRAS INSTITUTE OF TECHNOLOGY with the Faculty staff. Faculty Advisor S. P. Hore, Professor and Head of the Faculty of Automotive Engineering, is in the center.

SAE Enrolled Students

STUDENT ENTHUSIASM ABOUT SAE extends all the way to Madras, India, where 33 of the 80 Automobile Engineering students at the Madras Institute of Technology are SAE Enrolled Students.

SAE activity at the Institute began in 1951, when SAE member Professor S. P. Hore became Head of the Faculty of Automobile Engineering. Since then, two other faculty members have joined SAE, and the SAE Enrolled Students have become one of the most active of the Institute's student groups. These groups are instrumental in organizing the various extra curricular activities which play such a vital part in modern technical education. During the mid-term vacation last year, for example, SAE students made an Industrial Tour to Bangalore and Bombay to visit many of India's largest automotive plants and research centers. "The Small Car for India," was the topic of a symposium held at the Institute in which some of the country's top engineers, such as K. N. Ramanathan, chief engineer of Standard Motor Products, participated.

Included in the 1960–61 program were lectures, films and visits to plants. A. E. L. Collins, managing director of Ashok Leyland Ltd., and V. R. Reddy, Education Officer of the South India Council of Technical Education, Government of India, were among those who spoke to the students. Film screenings included "Spring," "Maintenance," "Mercedes-Benz Races Again," and "The Volkswagen Story." Among the plants visited were Standard Motor Products of India, Ashok Leyland, Ltd., Enfield India, Ltd., Simpson & Co., Odham Batteries, Integral Coach Factory, Carborundum Universal, Ltd., State Transport Workshops, Tranco Valves, Ltd., Dunlop Rubber & Tyre Co., Metal Box Co., Indian Air Force Training School, India Pistons, Addison Paints & Chemicals, Wheel & Rim Company of India, Addisons Foundry, Sundaram Motors, Government Industrial Estate.

The accomplishment of such programs, typical of any one year's SAE Enrolled Student activities, is under the guidance of Faculty Advisor Hore, who was himself an SAE Enrolled Student while at the University of Michigan. Professor Hore was graduated from the department of Mechanical Engineering of Calcutta University in 1941, and received his Master's Degree from the University of Michigan in 1947. He worked for Kaiser-Fraiser Corp. at Willow Run, Michigan until 1949, when he returned to India. Also in that year, Hore became an SAE member. He worked in the Defence Department of the Govenment of India for two years before joining the Institute.

A residential college with a present enrollment of about 300 students, Madras Institute of Technology was established in 1949 to offer graduates in physics, chemistry and mathematics three year courses of instruction in Automobile Engineering, Aeronautics, Electronics, and Instrument Technology. The Institute is the only school in India where automotive engineering is taught at the graduate level. The Institute's aim is to meet the growing demands of the manufacturing and transport industries for men with scientific and technical knowledge of design, development, and production "know-how."

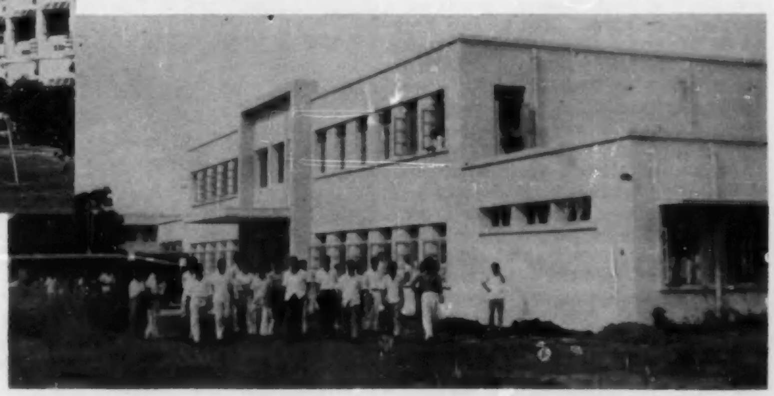
To bridge the gap between the purely theoretical scientific training of the graduate entrant and the requirements of technological studies, all first year students follow a basic engineer-

FACULTY ADVISOR S. P. HORE (far right) discusses an article from SAE Journal with Assistant Professors Narayana and Fernandes.

STUDENTS TEST A LEYLAND COMET 90 diesel engine coupled to a hydraulic dynamometer and electric indicator in the Institute's Automotive Engineering Laboratory.

Active at India's M.I.T.

A VIEW OF THE INSTITUTE'S CAMPUS, showing some of the dormitory buildings (left), and the newly constructed building for Automotive Engineering, which is ready for occupancy this year.



Madras Students

continued

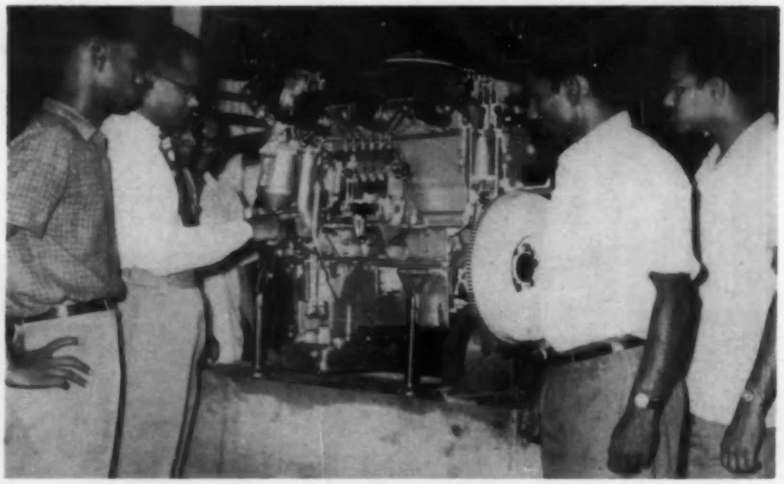
ing course. The second and third years are devoted to specialized training in one of the Faculties.

The curriculum in Automobile Engineering includes lectures in internal combustion engines, engine details, diesel engines, chassis, transmission, body engineering, auto electricals, transport, workshop technology, industrial management, measuring and gauging, mathematics, theory of structures and theory of machines; classes in machine drawing and design and drafting; design projects in engines, chassis, and jigs and tools; practical instruction in auto lab, auto workshop, general workshop, fuels and lubicants lab, and testing lab; technical report and seminar.

Ready for occupation this year, the new building for the department of Automobile Engineering houses the lecture halls, drawing halls, library, staff rooms and laboratory. The laboratory is equipped with three dynamometers; 150 bhp, 350 bhp hydraulic, and 150 bhp eddy current type. Instrumentation is provided for the measurement of power, torque, fuel consumption, air consumption, mechanical efficiency, ignition, timing, engine temperatures. The Auto Workshop is fully equipped for instruction in all servicing and reconditioning procedures.

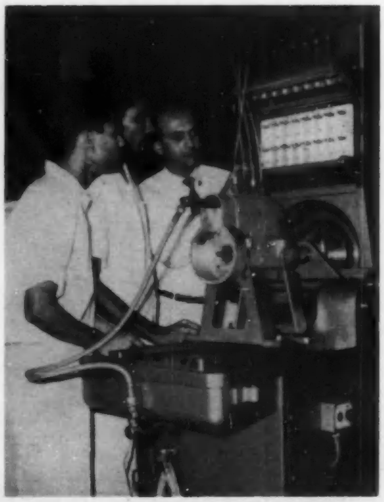
In addition to Professor Hore, there are two Assistant Professors on the faculty who are SAE members; N. N. Narayan Rao and A. V. J. Fernandes. Rao took his degree in Mechanical Engineering from Madras University in 1947 and was engaged in research and development in the department of internal combustion engineering, Indian Institute of Science, Bangalore, until he joined Madras Institute in 1955. He has published a number of papers in the fields of heat transfer, thermodynamics and engines, and he has been an SAE member since 1957. Fernandes became a member of SAE in 1959, having received his Mechanical Engineering degree from Madras University in 1949. Before he began to teach at Madras Institute of Technology in 1951, he was a lecturer in Mechanical Engineering at Annamalai University and assistant engineer in the transport section of the Burmah Shell Installation.

SAE members among the alumni of the Institute include: K. G. Pillai, principal, Government Polytechnic, Ujjain; M. R. Laxmi Narasimhan, captain, EME Corps, Indian Army; R. Chellappa, senior jig & tool draftsman, E. G. Irwin & Partner, London.



STUDENTS ARE INSTRUCTED ABOUT some of the salient features of a P6 diesel engine.

STUDENTS CHECK THE DYNAMIC BALANCE of the front wheel of a car.



PROF. A. V. J. FERNANDES (far right) and students observe calibration and phasing of a diesel fuel injection pump.

STUDENTS CARRYING OUT A TORSION TEST in the materials testing laboratory.

Indirect Labor Control Saves 15-25%

Based on report by secretary

H. F. MURRAY

Douglas Aircraft — Santa Monica

SAVINGS of 15–25% can be expected from indirect labor operations subject to control. The steps in developing such control are:

1. Survey present operations and methods, including the paperwork systems. (Surveys are best performed by objective analysts from outside the department being surveyed).
2. Select suitable units of measurements — purchase orders, receiving reports, units received, are examples. Place time values on these units. Analyze historical records. Make time studies and work samplings. Time individuals in preassigned tasks.
3. Set up reporting system.
4. Make recommendations for changes in personnel, layout, procedure, and such.
5. Make periodic analyses of units of measurement to record improved performance.

In a typical production control operation, the work force was reduced from 22 to 17 people. In addition, procedures were improved and standards developed to help detect trends and permit corrective action in the future.

(Based on report of discussion at panel on Performance Measurement Techniques — **S. J. Sullivan**, Douglas Aircraft — Santa Monica, chairman; **J. G. Byrne**, North American Aviation — Rocketdyne Division, co-chairman; **J. F. Knapp**, Direct Hours Control & Time Standards, Lockheed Co.; **D. W. West**, Management Services Div., Ernst and Ernst.)

Air Force Evaluates High Temperature Fuels

Based on paper by

J. R. FULTZ

Wright-Patterson Air Force Base

WHILE no individual compound is likely to be found which fulfills all specifications for a high temperature fuel, the alkyl-substituted monocyclics and the alkyl-substituted condensed bicyclics are most promising. Optimization of fuel properties using these two basic structures can be obtained by adding the proper number and size of sidechains to the basic molecule. These conclusions are reached after evaluation of more than 200 materials representative of the general types of hydrocarbon structure.

When a special fuel is needed, the isoparaffin structure is best suited for a weight-limited fuel application; for an extreme high density fuel the condensed tricyclic structure offers the best compromise of properties.

Fuel for Mach 5

The basic condensed bicyclic structure also appears most promising for that advanced vapor fuel which is now thought will extend the flight speed of advanced systems beyond Mach 5. The endothermic-type fuel will be needed for greater speeds or for desirable additional cooling below Mach 5. Studies of this type of fuel have established that the reaction products will perform satisfactorily in the combustor. Several hydrocarbons thus far tested have behaved excellently in the endothermic reactor as regards per cent conversion, gas and coke formation, and heat sink capacity.

To Order Paper No. 431B . . . from which material for this article was drawn, see p. 6.

Simple Rig Aids Fuel Spray Studies

Based on paper by

NELSON T. MECKEL, DONEL R. OLSON

and

R. D. QUILLIAN, JR.

Ordnance Fuels & Lubricants Research Laboratory

Southwest Research Institute

SIMPLICITY and excellent visibility are features of an apparatus developed for study of fuel injection spray characteristics in compression-ignition engines.

The apparatus consists of a GM Model 71 diesel engine unit injector and actuating mechanism, a variable-speed drive unit, fuel system, liquid-filled observation chamber, and stroboscopic lighting equipment. A standard engine cylinder head was modified by sectioning and raising the cam follower bores to locate the camshaft above the cylinder head combustion surface, and there is a special camshaft bearing housing and supporting structure. Actual engine parts were used to duplicate injector plunger speed, travel, acceleration, and the like during engine operation.

Wide Observation Possible

The camshaft is connected to the drive unit by a short shaft with flexible coupling at each end. A micrometer, mounted on the frame, controls the position of the injector rack

continued on p. 116


ENGINEERING
DEPT.
19

through a spring-loaded extension. The injector sprays fuel into a clear plastic hemisphere filled with liquid at atmospheric pressure. This chamber permits observation of the sprays for 360 deg in the horizontal plane and 180 deg in any vertical plane. A Strobolux unit illuminates the chamber and is triggered from a magnetic pickup located adjacent to the camshaft. The flash occurrence can be varied infinitely with respect to camshaft position in order to permit spray observation at any time. And by directing the light on a quadrant mounted on the camshaft, the time of the flash occurrence can be determined in engine crankshaft degrees.

The fuel system was designed to make changing of fuels very easy. Usefulness is also enhanced by the fact that conditions of speed, rack setting, and observation time can be established easily and accurately, and these conditions can be reproduced exactly for comparative tests.

To Order Paper No. 436A . . .
from which material for this article was drawn, see p. 6.

Manager Controls Improve In Numbers, Effectiveness

Based on panel secretary's report by

R. H. LINCOLN

North American Aviation Corp.

PRACTICAL management control techniques have grown greatly in number, scope, and effectiveness in recent years.

The PERT system, for example, has been developed to provide a total integrated system approach to solving complex, concurrently functioning activities. Operations research is another technique which is becoming increasingly helpful — though it is not adaptable to all kinds of problems. Operations research uses physical laws to find real relationships between situations . . . and serves management by "recommending" ways to manipulate these situations.

At the operating level, control techniques are informing engineering managers of the financial controls. They are bringing best results when the engineering manager is given freedom to operate within his budget. Some companies are getting best results by placing budgetary control on the lowest possible level of supervision — and by providing the necessary controls and information for good cost visibility.

In other companies, emphasis is being placed on "reality-centered leadership." Here, a manager must determine the role the future supervisor will play. He must consider the decision-making, job pressure, the people to be supervised, and the personality of the organization.

Subordinates and superiors in some

companies are being asked to develop together their plan of progress by starting with development of a job activities list. From this, standards of performance are developed and performance is measured against them.

To produce effective managerial control, experienced executives emphasize, a manager must have sensitivity. He must understand himself and others. He must develop the skills necessary for fruitful inter-personal relationships. He must think in terms of other persons' interests.

The technological obsolesence of people and "replacement" by retraining to cope with new advances are definite challenges to effective management control, also. To facilitate meeting these challenges, some experts urge that industry be given a chance to take tax deductions or to gain a return on training, such as the depreciation return on short equipment life. Such motivation, it is thought, might well provide the necessary financial backing needed for the monumental program that faces American management in retraining its work forces.

(Based on report of discussion at panel on Management Control Techniques — H. G. Henry, North American Aviation Corp., chairman; J. A. Reres, Operations Research, Inc.; Herbert Millstein, Operations Research, Inc.; John Truesdale, Operation Engrg. Control, Lockheed, Missiles & Space Co.; P. L. Engle, North American Aviation, Atomics International; John Larband, North American Aviation, Autonetics Div.; F. Roberts, North American Aviation, Aeronautics Div.; R. Horrworth, North American Aviation, Rocketdyne Div.; M. Gordon, Professor, Valley State College.)

Inexpensive Ways to Improve Reliability

Based on paper by

G. W. Weber
General Electric Co.

MANUFACTURERS can do many relatively inexpensive things today to improve tomorrow's reliability in their products. What these things are might be summarized into a program which would involve:

Learning with your customer to measure reliability quantitatively, starting with todays products. To do this, the manufacturer should start by establishing mutually acceptable failure definitions (consequence categories) and data accumulation procedures. Then a reliability processing system and qualitative reliability goals should be established. And finally, failure analysis should be conducted on all failed components to establish better elemental failure rate data.

Developing reliability prediction rate techniques and exercising them on today's products to establish needed correlations with measured values. . . . This competence should be developed in a corps of reliability engineering specialists, organizationally and geographically close to the product design engineer. Their challenge should be to predict or evaluate potential reliability and to measure achieved reliability; not to dictate decisions.

These techniques for predicting inherent reliability of proposed designs involve:

- defining a tentative mechanization of the design in as much detail as as possible.
- listing probably failure events or modes of failure for those design elements with highest likelihood of failure.
- tracing each of these failure events to its probable consequence at the product "output" level.
- summing the failure rates by major consequence category.

Use these reliability techniques to guide conceptual design work and to establish program needs at the proposal stage.

These guide techniques should include:

- review of reliability needs of potential markets.
- review of reliability obtainable through using state-of-the-art components and technology.
- review of possible special approaches and programs needed to reconcile these two factors.

Include special finding in proposals for mandatory reliability demonstration tests.

(A good statistical estimate of the overall reliability of complete products whose failure rate requirement is 0.005 failures-per-hr can be obtained economically).

Design all development testing for maximum test effectiveness. Surrender the objective of *measuring* reliability where necessary.

The easy-to-define, simple reliability demonstration test is highly inefficient in identifying design deficiences that must be fixed . . . . and in proving the adequacy of a fix.

The direct benefits and general profitability of a long-range reliability program is difficult to predict in advance. But the benefits redound to the producer in reduced losses in test and manufacturing, in reduced development cycles, and in reduced redesign and retrofit costs.

■ **To Order Paper No. 418B . . .** from which material for this article was drawn, see p. 6.

Briefs of SAE PAPERS

continued from p. 6

Full Flow Filtration — Must in Engine Economy, W. G. NOSTRAND. Paper No. 388A. Standard requirements of full flow filter which are of critical importance to internal combustion engines as applied to trucks, tractors, logging equipment, marine, aircraft, etc.; types of filters such as "cloth" or "bag" type element to meet low pressure loss requirements, single density "depth type" media, and modified depth type filter with its 2 density structures; test results obtained with Winslow heavy-duty 2-density full flow filter.

Servicing and Maintaining Modern Machine, J. W. RIESING. Paper No. 388B. Outline of controlled maintenance program featuring service, repair, and replacements based on tests for unit rather than scheduled at arbitrary mileages; how it works; use of spectrographic laboratory system of controlled maintenance in conjunction with other methods of control.

Development of Hydraulically Shifted Tractor Transmission, L. E. ELFES. Paper No. 391A. Approach used by Massey-Ferguson Ltd. in developing "MultiPower" transmission for MF 65 tractor, which is shift on the go transmission providing shifting while in motion, without interruption of power flow, with tractor in each of its 6 manually selected gear ratios, or total of 12 forward and 4 reverse speeds; problems involved in developing overrunning clutch; finally selected clutch of jaw type featuring automatic lockup; results of tests.

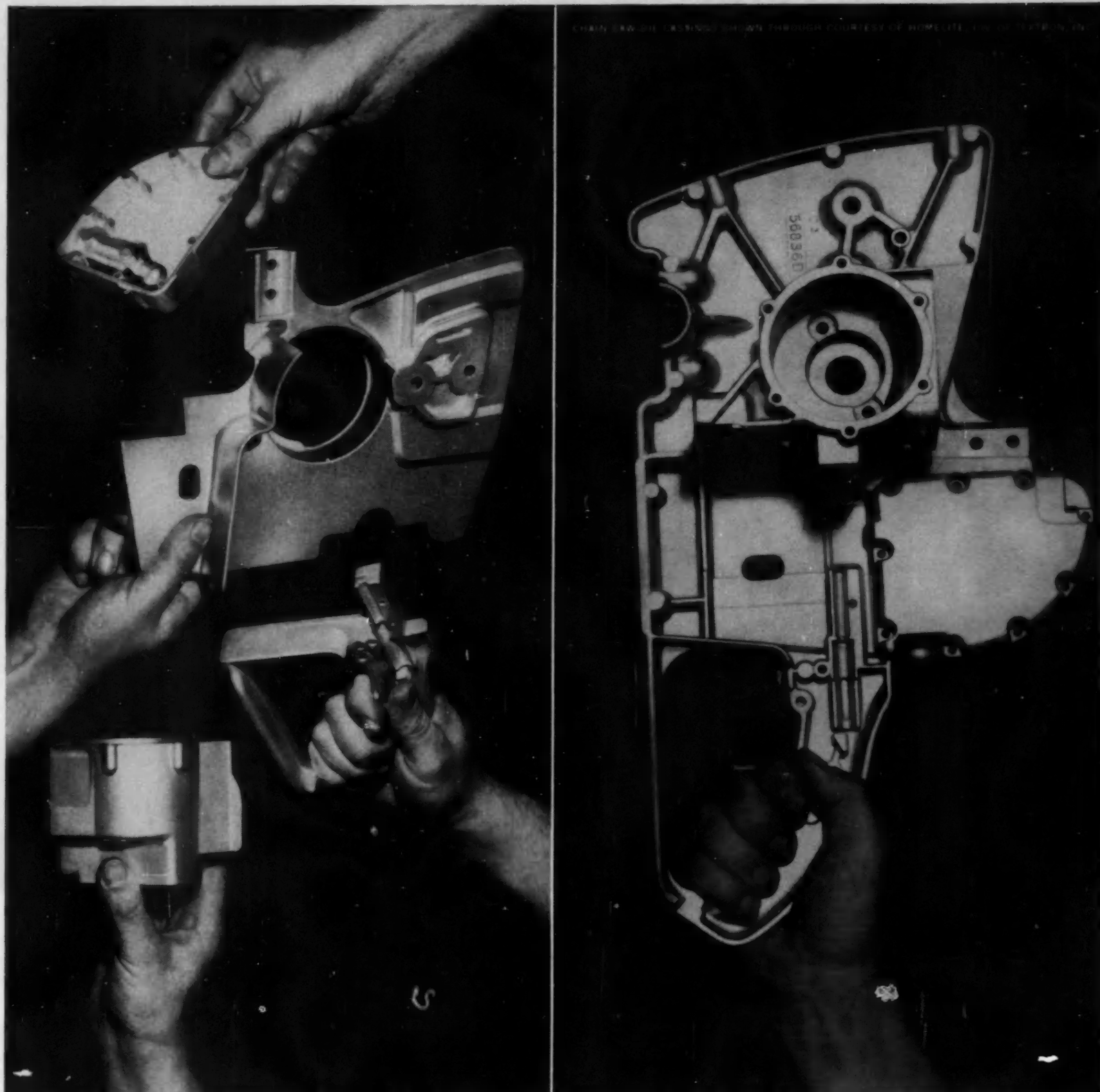
4-Wheel Drive Tractor for Large Farms, W. J. ASKINS. Paper No. 391B. Design and development of rubber tired tractor, by Frank G. Hough Co.; tractor can be roaded easily at speeds up to 25 mph, while top speed of crawler tractor is around 8 mph; 375-hp turbocharged diesel engine, derated to 300 hp by limiting fuel to injectors, is used; details of transmission, steering, brakes, clutch and controls; field tests.

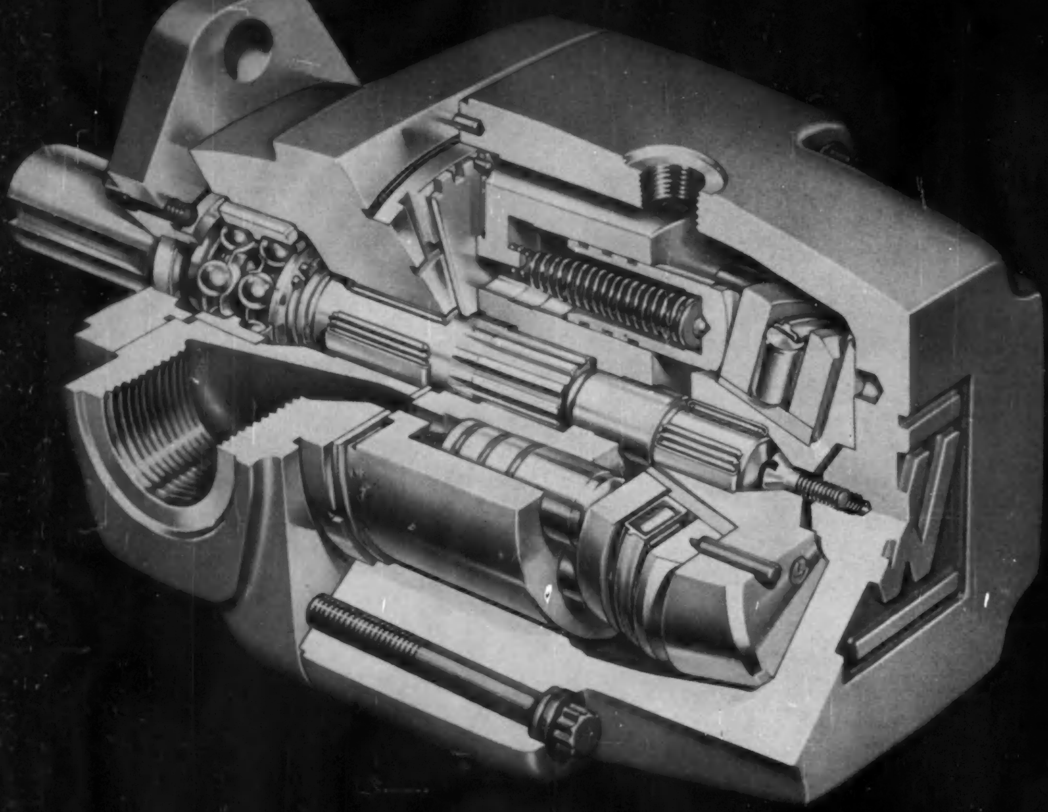
Ford 6000 Tractor, C. T. O'HARROW, C. B. RICHEY, B. G. BURNSIDE. Paper No. 391C. Development aspects of "6000" series; new styling divides grille, hood and instrument section into 8 major parts; ease of operation of Select-O-Speed Transmission control, located at right hand side of steering wheel and PTO (power take-off) power control for engagement and disengagement of PTO clutch on independent type PTO system; Ford Select-O-Speed provides on-the-go shifting, under full load, throughout 10 forward and 2 reverse speeds; specifications of 6-cyl engines for diesel fuel and gasoline.

New Military Design Engines, G. R. CONRAD, R. F. DENNIS, W. A. SUMMERSON. Paper No. 392A. Development of general purpose power units ranging from ½ to 20 net continuous hp, suitable for driving military equipment, electric generators, air compressors, earth augers, air conditioners, pumps, etc., operating under arctic, desert, and tropic environments; engine specifications; design and construction of model 4A084 20-hp, 4-cyl, overhead valve, aircooled, gasoline engine; lubricating and winterization systems; arctic test data from Model 2A042 10-hp engine.

Three-Point Hitch Mounted Picker, D. D. DANKEL. Paper No. 393A. Design objectives and development of 2-row corn picker and picker sheller by Motec Industries, Inc.; implement can be mounted by one man in less than 1-min and lifting is accomplished by power unit of tractor; operational features and performance; novel features incorporated which afford positive

continued on p. 121





WEBSTER'S NEW C3F PISTON MOTOR AND PUMP

compact, simple design ■ exceptionally serviceable!

This new hydraulic power unit — developed especially for the machine tool field — features unique application and servicing advantages. Examples: (1) small "package" to fit in close quarters — SAE "A" size mounting can be used with easy access to both mounting holes; (2) simplest axial-type piston pump on the market — fewest parts, fewer potential trouble spots, greater economy; (3) easily serviced — all critical moving parts can be readily replaced in the field. Shaft can be exchanged by disassembling seal end only; (4) unit can be disassembled and the rotation reversed in the field — can be arranged for use as a dual rotation motor; (5) variety of mounting styles — mounting plate and seal assembly is a separate piece and can be furnished in several mounting styles; (6) drive shafts are available with keyways or splines.

The C3F Series can be used as a hydraulic motor (remote rotary locations, screw feeds — anywhere an electric motor might be used) or as a hydraulic pump . . wherever high torque and smooth, steady force are required. It is available in four sizes — from .72 to 1.81 cubic inches per revolution. Capacities range from 3.3 to 8.5 gpm at 1200 rpm; 7 to 18 gpm at 2400 rpm.

C3F SERIES

FIXED DISPLACEMENT AXIAL-TYPE PISTON MOTORS AND PUMPS

Drive: direct, gear or belt

Displacements: four sizes; .72, 1.09, 1.45, 1.81 cu. in. per rev.

Porting: Side ports — horizontal or vertical — handle 1" NPT inlet or 1¼" "O" ring straight thread

Capacity: 3.3 to 8.5 gpm at 1200 rpm
7 to 18 gpm at 2400 rpm

Speeds: to 3000 rpm

Pressures: continuous duty 3000 psi, intermittent rating to 3500

When used as motor:

Torque range (theoretical): four sizes; 11.52, 17.28, 23.04, 28.80 inch pounds per 100 psi

Output: 5.5 to 14 hp. at 3000 psi at 1200 rpm
11 to 28 hp. at 3000 psi at 2400 rpm

OIL HYDRAULICS DIVISION
WEBSTER ELECTRIC
RACINE · WIS

franklin adv. H127A

Briefs of SAE PAPERS

continued from p. 118

gathering and delivering of corn stalks and prevent loss of ear corn sliding down rolls and out to ground.

How to Drive It; How to Steer It — Self-Propelled Conundrum, J. BORLAND, D. C. HEITSHU. Paper No. 393B. Analysis of self-propelled chassis with respect to possible configurations of drive and steer is divided into conventional differential drive with mechanical steer and 8 different combinations thereof, and independent wheel drive with full control and 4 possible designs; advantages and disadvantages of each combination and applications on combines on farm, lift trucks, small loaders, scrapers and wagons.

Small European Engines, Status and Recent Developments, W. E. MEYER. Paper No. 394A. Survey of single cylinder, aircooled, high speed engines of up to 10 hp for lawn mowers, pumps, and generators small tractors, construction machinery, etc.; examples of 2- and 4-stroke gasoline engines, such as BWM 403 engine, 7.2–8.3 hp at 3000–3600 rpm, Bernard W110 engine, 4 hp at 2500 rpm, and Berning D6 engine, 6.7 hp at 3000 rpm; 2- and 4-stroke diesel engines: Fichtel & Sachs 600, 10 hp at 2000 rpm; Sendling DL 107, 4 hp at 3000 rpm; Petter PC 1, 5–6 hp at 3000 rpm, etc.

Climatic Control for Air Cooled Engines from Tropic Heat to Arctic Cold, J. A. GRESCH, R. D. BEARD. Paper No. 394B. Industrial military engines fall into nonwinterized and winterized types; 125 F ambient temperature has super-imposed upon it requirement of starting and operation after minimum of exposure of 4 hr with full impact of solar radiation; development by Wisconsin Motor Corp. of engine enclosure system, sustaining itself over temperature of +125 to −65 F, while meeting requirements of MIL-E-11275 engine specifications; work performed on Wisconsin 2-cyl MTHD engine.

John Deere Sleeve and Deck Engines, W. H. NORDENSON, R. CANDEE. Paper No. 395A. Range of basic gasoline, LP, and diesel 4- and 6-cyl engines incorporating sleeve and deck fabricated assembly in simplified cylinder block, developed by John Deere Dubuque Tractor Works; various applications; design and development of sleeve and deck assembly, made up of machined deck plate and set of cylinder sleeves brazed into assembly; all sleeve and deck assemblies of given bore size and number of cylinders are interchangeable, whether for gasoline or diesel; manufacturing aspects.

Development of Oliver's New Gasoline Engine, T. H. MORRELL, K. S. MINARD. Paper No. 395B. History of X0-121 development (12:1 compression ratio for tractor engine) and additional studies by Ethyl Corp.; using X0-121 type combustion chamber, modified Super 88 engine was tested at various compression ratios and results compared to those obtained for X0-121; areas requiring further development included combustion chamber configuration, spark plug location, manifolding, camshaft and valve timing; tests conducted, evaluation and comparison of test results.

Parking Requires Brakes Too, R. E. DIX. Paper No. 396A. Brakes for parking are divided into those installed in heels (usually rear), on transmission case or differential (or both), and working on driveshaft; systems employing hydraulically actuated brake with internal linkage or existing mechanical brake (usually actuated by air), energized by separate mechanical linkage; parking brake requirements set up by government agencies and summary of state regulations; examination of forces acting on vehicle negotiating grade; future improvements.

Emergency Brakes, R. F. BURRIS, A. D. McLEAN. Paper No. 396B. Paper deals with air actuated, cam type foundation brake systems; review of early developments and types of mountings used; procedure for evaluating spring brakes applied at Kenworth Motor Truck Co., Div. of Pacific Car Foundry Co.; examples of typical units, such as MGM Model 410 axle or frame mounted unit, Bendix-Westinghouse Model 275161, Maxi Brake Inc., Model 30-60-Ci and Model 30-60-Pl; Berg Manufacturing Co., Model 1784, HydroAire Co., Model 10-030, etc.

Retarders for Highway Vehicles, E. C. MAKI. Paper No. 396C. Review of basic types, such as hydraulic retarders, fluid cooled disk brakes, electric retarder as offered by Lear, and engine exhaust brake; advantages and disadvantages of retarders; examples of field experience.

Fuel Control Systems for Small Gas Turbines in England, J. S. CLARKE, C. K. J. PRICE, C. H. BOTTOMS. Paper No. 398D. Controls and control techniques suitable for gas turbine engines used for road transport vehicles or stationary equipment; requirements and individual control functions of fuel sprayer, ignition, starting and acceleration controls, governor and temperature controls; details of basic system consisting of fixed stroke axial piston pump providing fuel to Simplex atomizer via shut-off cock; suggested fuel system suitable for automotive purposes; use of gaseous fuels.

Design and Development of Two New Industrial Gas Turbine Fuel Controls, F. W. NEWBURGH, B. INGOLD. Paper No. 398E. Peculiarities of gas turbine which require fuel control; principles applied at Woodward Governor Co. to Type 1945 design of simple control for low compression, low altitude gas turbines; Type 1910 design for high compression ratio engines in 1000–

continued on p. 123

Briefs of SAE PAPERS

continued from p. 121

20,000 hp class; control parameters to consider: engine rpm, engine compressor inlet temperature and discharge pressure, engine rpm operator or pilot requests, and angle of variable compressor stators; free turbine application.

New Power Steering System for Tractors, E. H. FLETCHER. Paper No. 400B. Outline of design objectives for larger tractors in new John Deere line; all hydraulic functions provided on 3000 and 4000 series tractors are integrated into central hydraulic system, made up of oil supply, hydraulic pump, control and supply lines, and power steering function, comprising steering valve and steering motor; operation of valves during power turn.

Control of Combustion of Compression Ignition Engines, E. T. VINCENT, A. R. IBRAHIM. Paper No. 401A. Study made at Univ. of Michigan using single cylinder 4-stroke diesel engine; effect of primary fuel injection was examined as regards timing, pressure, cooling water temperature, engine speed, and fuel additive, upon engine performance and lag to define optimum condition; test results show combustion lag depends to definite degree upon precombustion reactions and that acceleration of both can be effected by encouraging such prereactions early in cycle.

Swirl and Combustion in Divided Combustion Chamber Type Diesel Engines, F. NAGAO, H. KAKIMOTO. Paper No. 401B. Research conducted at Kyoto Univ., Japan, to determine effect of air-swirl on combustion in small high-speed diesel engines; combustion control by means of combustion swirl; combustion in pre-chamber type engines, and in Lanova air-cell type engines; particular attention was paid to improvement of maximum output and thermal efficiency, reduction of noise and exhaust smoke. 29 refs.

Some Aspects of Truck Drive Train Vibration Problem, M. C. KAYE. Paper No. 402A. Aspects of drive train vibration embrace universal joint vibration, propeller shaft critical speed, engine mounts, and comparison of human response to sound and vibration; features of universal joint vibration are reviewed and rules, found successful in keeping vibration levels within tolerable limits for trucks as applied at Freightliner Corp., outlined.

Drivelines for Heavy Equipment, J. A. KAYSER. Paper No. 403A. Equations are given which can be used for calculating characteristics of Carden universal joint when operating angle

continued on p. 125

Briefs of SAE PAPERS

continued from p. 123

is small; 3 factors to be considered: inertia excitation, torsional excitation, and secondary couple forces; facts which must be known to determine satisfactory application include installation and experience factors; examination of these factors for highway truck type of application.

Application of Universal Joints to Construction and Industrial Machinery, W. T. CONDON. Paper No. 403B. General design principles of universal joint; factors to consider include static torsional capacity and its dynamic bearing capacity, information and data which will minimize problems resulting from nonuniform displacement, velocity and acceleration produced by joint, and avoid operating shaft near its natural bending frequency; knowledge required of operating conditions which includes torques, speeds, angles, and environmental conditions.

Farm Equipment: Growing Challenge for Industrial Designer, J. GALE, G. T. SCHARFENBERG, J. N. POLIVKA. Paper No. 404B. History of development of farm machinery, and trends introduced after World War II with respect to styling of farm implements; factors which must be considered in addition to basic function of machine such as comfort and human engineering, ease of maintenance etc.; example of medium duty sweeper manufactured by G. H. Tennant Co., redesigned and styled by Scharfenberg-Polivka-Gale, Inc.; Owatonna Mfg. Co. windrower, and other examples.

Fork Lift Truck Stability Design Criteria, L. K. JENSEN. Paper No. 405B. Inherent stability of cantilever type truck is determined by height of center of gravity and its location between drive and steer axles; stability factor ratios for determining lateral and longitudinal stability of truck are used to make up for indeterminate effect on stability of upright deflection, upright looseness, tire, carriage, fork and frame deflection, and steer axle articulation; recommended stability tests and minimum requirements for each test.

Seventh L. Ray Buckendale Lecture — Design of Single-Stage Three-Element Torque Converter, V. J. JANDASEK. Paper No. SP-186. Function of converter explained in elementary terms and details involved in design with respect to circuit size, performance analysis, flow circuit, and blading; fabrication techniques and other performance considerations; converter fluids.

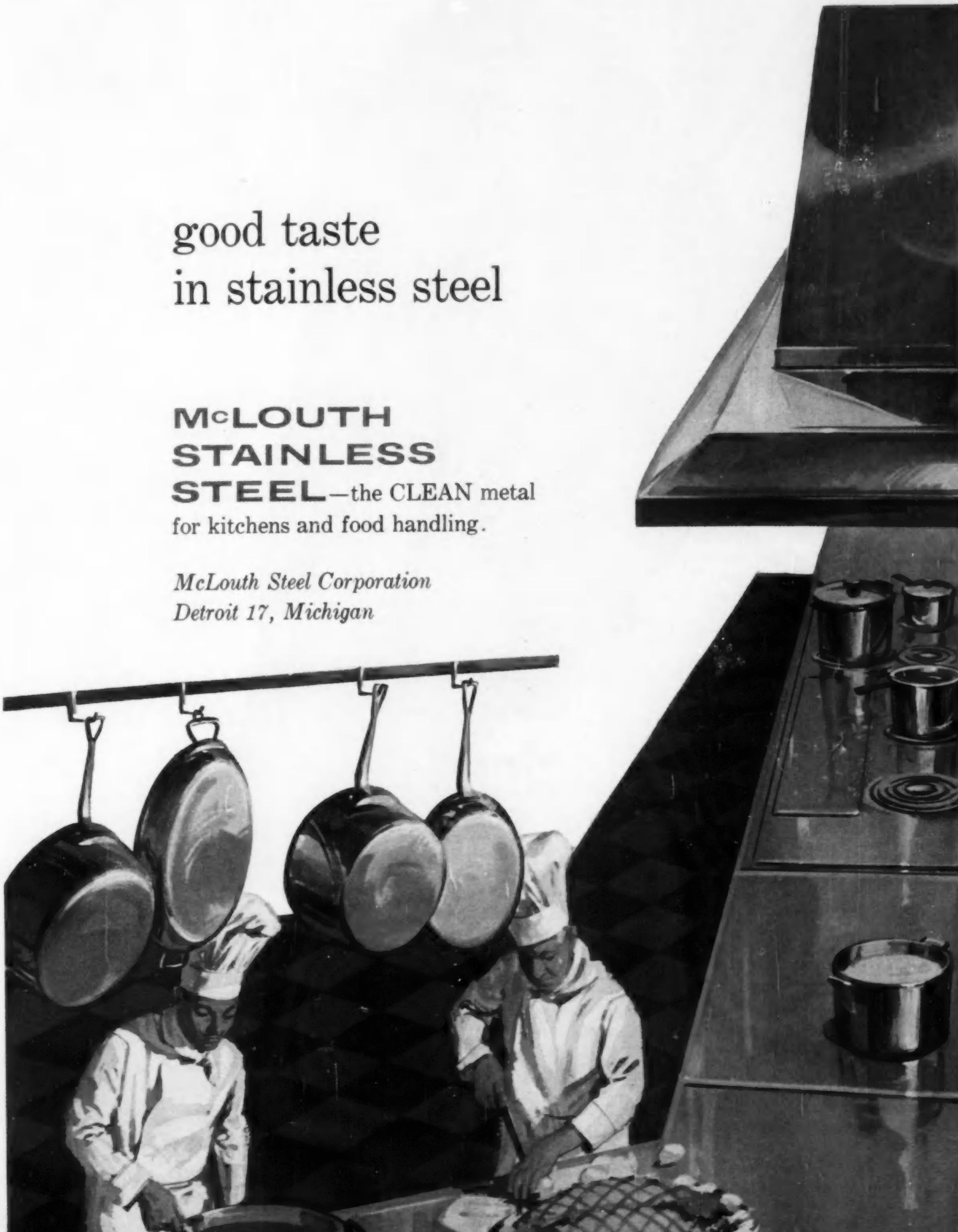
Alternators: Types, Advantages, and Applications, W. C. EDMUNDSON. Paper No. S311. Shows that, to increase the life of alternators, the life of bearings, brushes, and voltage regulators must be increased. Details and describes various types of alternators currently in use — and discusses optimum applications of each.

MISCELLANEOUS

Some Aspects on Bow Thrusters for Great Lakes and Inland Waterways Vessels, H. H. SCOTT. Paper No. 376A. Reasons for interest in bow thrusters, defined as device in forward part of vessel which exerts strong and continued pressure endwise through propeller shaft submerged in water; its elements are source of power, transmission system, propeller and surrounding hull structure, and controls; existing types, operating in transverse tunnel through hull or in cut-out section at bow; factors to consider in selection of unit; various U. S. installations.

Vehicular Electronics 1970 — Telephone Exchange in Your Glove Compartment, A. J. RUNFT. Paper No. 390A. Areas attractive for future application are guidance and control, safety, and communications; electromagnetically radiated or inertial systems can be used to guide vehicles em-

continued on p. 129


good taste
in stainless steel
McLOUTH
STAINLESS
STEEL—the CLEAN metal
for kitchens and food handling.
McLouth Steel Corporation
Detroit 17, Michigan

Briefs of SAE PAPERS

continued from p. 125

ployed in farming, mining, and road construction; electronic highway system to keep track of vehicle position and to maintain intervals between vehicles; details of 2-way radio telephone equipment for automobiles, and aircraft, Chieverfone and Skyphone, under development at AC Spark Plug Div. of General Motors.

PRODUCTION

Aluminum Casting at Central Foundry Division, General Motors Corporation, J. LAPIN. Paper No. 389B. Summary of experience gained with sand molding, semi-permanent mold, permanent mold, and die casting at Central Foundry Div. of General Motors; to reach proper decision on optimum casting process for given part, it is necessary to evaluate process factors, such as part design, product performance, cost/piece, lead time and turnaround factor, capital investment, sales and economies; details of each process.

Die Casting from Technical Viewpoint, R. STENBERG. Paper No. 389C. Factors which must be considered when planning to introduce additional die castings in tomorrow's automobile: experienced personnel, proper casting design, suitable labor contract, properly designed die cast dies and accompanying tools, building constructed for die casting, proper maintenance facilities for dies and machines, and good quality control program.

Versatility of Aluminum Sand Casting Process, A. H. HINTON. Paper No. 389D. Recent developments in pattern making and molding, with particular reference to casting of automobile components; by increasing speed of solidification in combustion chambers and taking advantage of more drastic chill, provided by either dry or green sand, increased properties in combustion areas of cylinder head from yield strength 22,000–23,000 psi, tensile strength 25,000–32,000 psi and elongation 1–4% were obtained.

Is Creative Design Being Shackled by Production Inertia? T. G. TIMBERLAKE. Paper No. 399A. Study made to formulate data which could be used inprogramming and planning earthmoving equipment developments conducted by U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va.; developments studied were grouped into product redesign, product engineering, and developmental engineering; tabulation of 16 equipment classifications, which represent combat essential earthmoving equipment development spectrum.

New Members Qualified

These applicants qualified for admission to the Society between September 22, 1961 and October 22, 1961. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section: James F. Frenchi (M), Joseph Christian Schwanebeck (J).

British Columbia Section: D. G. Lenzen (A), William Hardy McQueen (J).

Buffalo Section: Bruce D. Kellner (J), Edward H. Wannenwetsch (M).

Central Illinois Section: Dempsey Woodrow Cochran (A), Richard Edward Maxwell (J).

Chicago Section: Edward N. Dickson (M), Gerald Jerome Farrell (J), Ralph S. Frost (M), Edgar Hadfield Hannum (M), Paul R. Knestrict (A), Wendell S. Linnell (M), Karle Baker Meyer (M), Stephen H. Paul (M), W. Van F. Schroeder (A), Lester C. Tiscornia (A), Joseph Francis Vosmik (J).

Cincinnati Section: Alfred F. Hegerich (A), Keith E. Terry (M).

Cleveland Section: Chas. F. Emish (M), Paul Allan Reid (M), Lloyd E. Skinner (A), Edward T. Vitcha (M), D. Brian Wheeler (M).

Dayton Section: David E. Bearint (M), Robert W. Pfeil (M).

Detroit Section: George Steve Aradan (A), Leonard George Cyr, Jr. (J), Duane Dennis Eichstaedt (J), Donald LeRoy Glossop, Jr. (J), Allen L. Goody (J), Lowell Atwood Hibbits (M), Thomas Floyd Hrynik (J), Richard Herman Johnson (A), Curtis Bryan Joyner, Jr. (J) Carl J. Koskinen (J), Howard E. Lang (M), Bernard Los (M), Alfred C. Metz, Jr. (M), Frank George Meyer (A), Richard J. Milliman (M), Richard V. Moxley (J), Donald Buell Pentecost (A), Henry W. Potoczak (M), Donald Max Scraver (J), Harley M. Selling (M), Roy Hamilton Sjoberg, Jr. (J), James R. Weller (M), Adolph E. Woltanski (M).

Fort Wayne Section: James C. Hoelzer (J), Forrest Denver Thomas (A).

Hawaii Section: Edwin R. Sorensen (J).

continued on p. 130

New Members Qualified

. . . continued

Indiana Section: Ralph Norman Binkley (J), James Burgoin Kelly (J), James E. Knott (M), Lawrence Robert Myers (J).

Kansas City Section: Carroll C. Moore (A).

Metropolitan Section: Mark Louis Auriana (J), Ronald Sherratt Gall (A), Charles Gallo (J), Dalton George Neudecker (A), James R. A. Walker (M).

Mid-Continent Section: Ellis Garlington, Jr. (M).

Mid-Michigan Section: Joseph K. Decker (M), Ronald Lee Harris (A), David Warrington Piper (J).

Milwaukee Section: Robert Dibble (M), Robert Kenneth Luft (J), Thomas Arthur Mulhaney (J), Herbert Thomas Roedel (J).

Montreal Section: Harry Hill (A), Fernand Edouard Morissette (J).

Northern California Section: Donald Curtis Patston (J), Philip Grayson Ruhle (J).

Northwest Section: Michael James Dempsey (J), James Willard Hathaway (J), Donald Louis Mellinger (J), Ivan Gordon Myers, Jr. (J), William Grant Nelson (M).

Ontario Section: Kenneth Cashmore (M), Albert Cimarosti (M), William M. Hood (A), David Victor Makuch (J), Donald Grant Norris (M), Ellis Joseph Sudding (A).

Philadelphia Section: Edwin R. Dunbar (A), William Howard Moore, Jr. (J), Olaf K. Szamody (A), Robert L. Thomason (A), Robert Van Fleet Tompkins (M).

Pittsburgh Section: Harry Walter Jacob (A), Paul Raymond Klauss (J), Richard W. Simon (M).

Rockford-Beloit Section: Ronald Wayne Nicolaus (J).

St. Louis Section: Kendall C. Crawford (J), Richard Eugene Kuster (J), Leonard Arnold Stein (A), Thomas Eugene Winter (J).

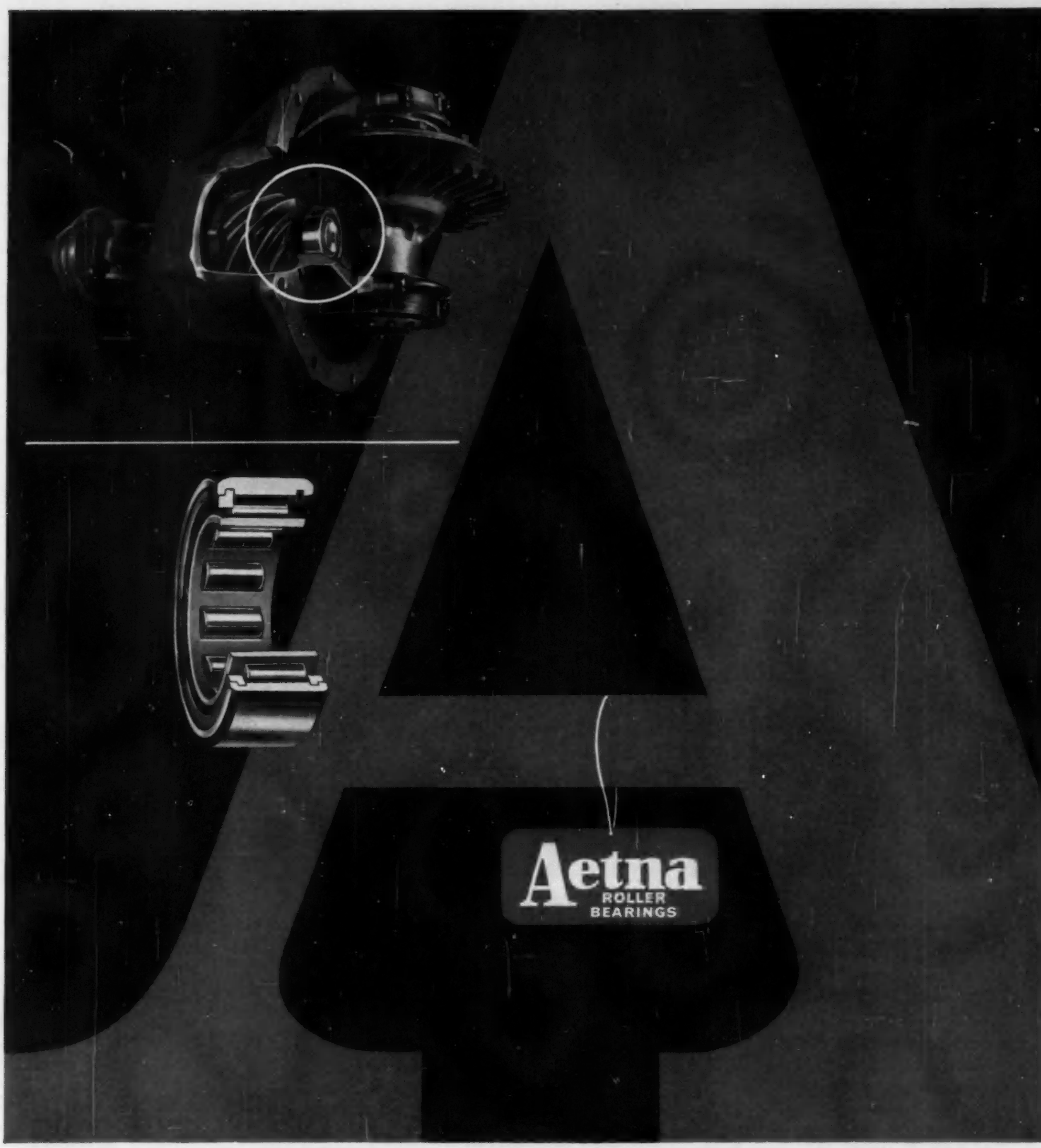
Salt Lake City Group: Yu-Hsin Chao (M).

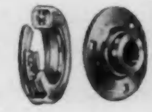
San Diego Section: Howard Oliver Earl (M), George Hayashi (J), William L. Johnston (M), Brian Boru Spillane (J).

Southern California Section: Ronald George Anderson (J), Gordon Seidel Chapman (J), Ward B. Dennis (M), James LeRoy Knowles (J), Nathaniel Levert (J), Clifford William Moore (J), Gerald Nels Ostrom (J), Robert B. Stewart (A), Granville Cook Stone (A).

Southern New England Section: Paul

continued on p. 133


Aetna
ROLLER
BEARINGS



New Members Qualified

. . . continued

John Fitzgerald (A), David J. Hirschfeld (J), Robert Norman Libsch (M), Charles F. Shelton, Jr. (M), Reginald James Smith (J).

Spokane-Intermountain Section: Colin John Sandwich (J).

Texas Section: Bobby Ray Harms (A).

Texas Gulf Coast Section: Ottie R. Eads (M), Fred Byron Hudspeth (J), Louis M. Landa, Jr. (A).

Washington Section: Karl Becker (M).

Western Michigan Section: James A. Dykema (M).

Williamsport Group: James Norwood Fleck (J).

Outside Section Territory: Robert L. Franklin (M), Ronald William Glasman (J), Jerry Ross Hochstatter (J), Rodger Alan Jump (J), Martin Joseph Paul (M), Roland P. Rebhorn (A), Elwin J. Salter (M), Herbert D. Sullivan (M), Gordon J. Wavrek (M), James Cecil Wilson, Jr. (M).

Foreign: Carlo Felice Bona (M), Italy; Wilfred Bright (M), Germany; Alberto Cory C. (J), Mexico; Francis Leslie Golightly (A), England; David Hodkin (M), England; Raul Martinez (M), Argentina; Robert Racine Pereira (A), Brazil; John Hezeward Pitchford (M), England.

Applications Received

The applications for membership received between September 22, 1961 and October 22, 1961 are listed below.

Alberta Group: Ernest Norman Cliff, William Henry Booth Crampton, Stanley Joseph Diachok, William Forbes Ellison, Gerald Stuart Fanning, John Edgar Fortune, Carl August Laudan, John Eric Lind, Arnold Peers Philipsen, Harold Ernst Reitmeyer, Arthur Edward Rothon, Peter Arthur Rothon, Donald Wallace Russell

Atlanta Section: Keith Allen Wardwell

Baltimore Section: Herman Bernard Groh

British Columbia Section: Norman Marvin Owen

Buffalo Section: Allan Richard McLouth, Edwin Stuart Shaffer

Central Illinois Section: Raymond Wetzel Hettiger

Chicago Section: Wendell Ray Baldwin, Edward F. Barrett, James F.

continued on p. 134

Applications Received . . . continued

Bere', Carl H. Beverly, Dennis R. DeLaura, Arnold John Freund, Earle G. Hamilton, James Lamar Hayes, Enoch J. Hoelacher, John Charles Lemak, Joseph Michael Neubauer, Robert Leopold Pirman

Cincinnati Section: Robert Edwin Ledbetter, Robert Lee Piercefield

Cleveland Section: Howard J. Anderson, James E. Belsan, Edward William Bremke, Jr., Robert W. Ellis, Frank Richard Frisina, Robert Neil Hepworth, Thomas D. Karcher, Donald Treese McClurg, Robert A. Otcasek, Allan Ray Putnam, Paul Barbour Readett, Jr.

Dayton Section: Andrew Jon Eggenberger

Detroit Section: David P. Anderson, Gaitskill Spayd Barr, William Joseph Bradley, Jr., Edward Hyde Burdick, Robert B. Dow, Jack G. Grellman, Douglas Neil Haulund, Beeler David Higbee, Jr., James Robert Johnston, Lawrence Roe Kirby, William Arthur Klug, Thomas Harry Lang, Norman Frederick Luther, Charles Farrell Maddox, Thomas Manos, Robert Leigh Mason, Donald Warren McDaniel, James Evan Morgan, Norman Peter Patterson, Norman Paul Peters, Lawrence James Rathgeb, Eugene Schaefranek, Howard Edwin Schultz, Thomas William Simpson, Robert Martyn Snow, Gordon Robert Sorenson, G. Gregory Stephen, Robert Earl Stobb, Edward William Szalay, Donald Charles Unger, John Vorobel, James Emerson Wallis, Ocie Kent Walthall, Donald Eugene Wente, Robert Paul Wheelock, Robert A. Wise, Paul Edward Young

Fort Wayne Section: Robert F. Stuck

Hawaii Section: Allen Smith Hall

Indiana Section: Robert Walter Campbell, Alpha Arnett Hamm, Louis John Stephanoff, Joseph Warren Stidham

Metropolitan Section: Robert Joseph Cerullo, Richard Fleming Creeron, Paul B. Croly, Joseph William Denneen, Walter De'Prey, Michael John Esposito, Jesse Fisher, Hugh Harold Harkins, Maurice Edward Nicklin, August Bartold Pedersen, Victor M. Rodriguez, Frederick Jay Shore

Mid-Continent Section: Homer Stewart Newby

Mid-Michigan Section: Stanley Earle Anderson, Gerald Allan Brouwer, Donald Arthur Butts, Darrell H. Dengler, Donald Andrew Fink, Douglas Gill, Lawrence Joseph Mahalak, Anthony Michael Parrottino, T. Charles Powell

Milwaukee Section: Donald Gene Haffner, Kenneth William Hammel, Richard F. Tymnick, Rolland Ordell Westra

Montreal Section: Calixte J. Dagneau

New England Section: Daniel Francis Pierre, Earl Stevenson Woods, Jr.

Northern California Section: Salvatore Henry Donze, Robert J. Jeffers, Richard Eugene Steinke

Northwest Section: H. Raymond Brown, Glen Alfred Devore, E. A. May, Gerold Wayne Mittlestadt, Ray Harold Reynolds

Ontario Section: Jan August Depuydt, William Stuart Gardner, John Hartley Girvan, Clifford Bruce Harrop, Robert Alan Hay, Reginald Stewart See, Leslie Herbert Skipper, Richard Warren Warkentin, Ralph A. Wilson

Philadelphia Section: Clarence Thomas Gilmour

St. Louis Section: Charles Richard Berreman, Archie R. Graham

San Diego Section: Enrique Passig Aguilera, Ernest F. E. Kling, Carnis Gene Kullman, David Mark Pettit, James Allan Steele, Hampton Long Teague, Steven Mitsue Uyehara, Edward James Williams, William E. Wise

Southern California Section: Donald Harris Brittingham, Murel Glenn Brown, William Edward Fix, Jr., Richard Douglas Kempf, Harold Edwin Kingsbury, William R. Kulda, George Robert Meyer, Wayne Richard Scherer, Darryl Wade Thompson, Robert Layton Townsend, Robert Max Weatherman, Paul O. Wierk, Manoochehr Yomtobian

Southern Texas Group: Cecil R. Sparks

Spokane-Intermountain Section: Lem W. Billingsley, George Howard Montague, Oscar Selden, William A. Steenbergen

Syracuse Section: Peter Ravel

Texas Section: Robert Edward Gast, Richard Allen Morrow

Texas Gulf Coast Section: Claude Warren Hunter

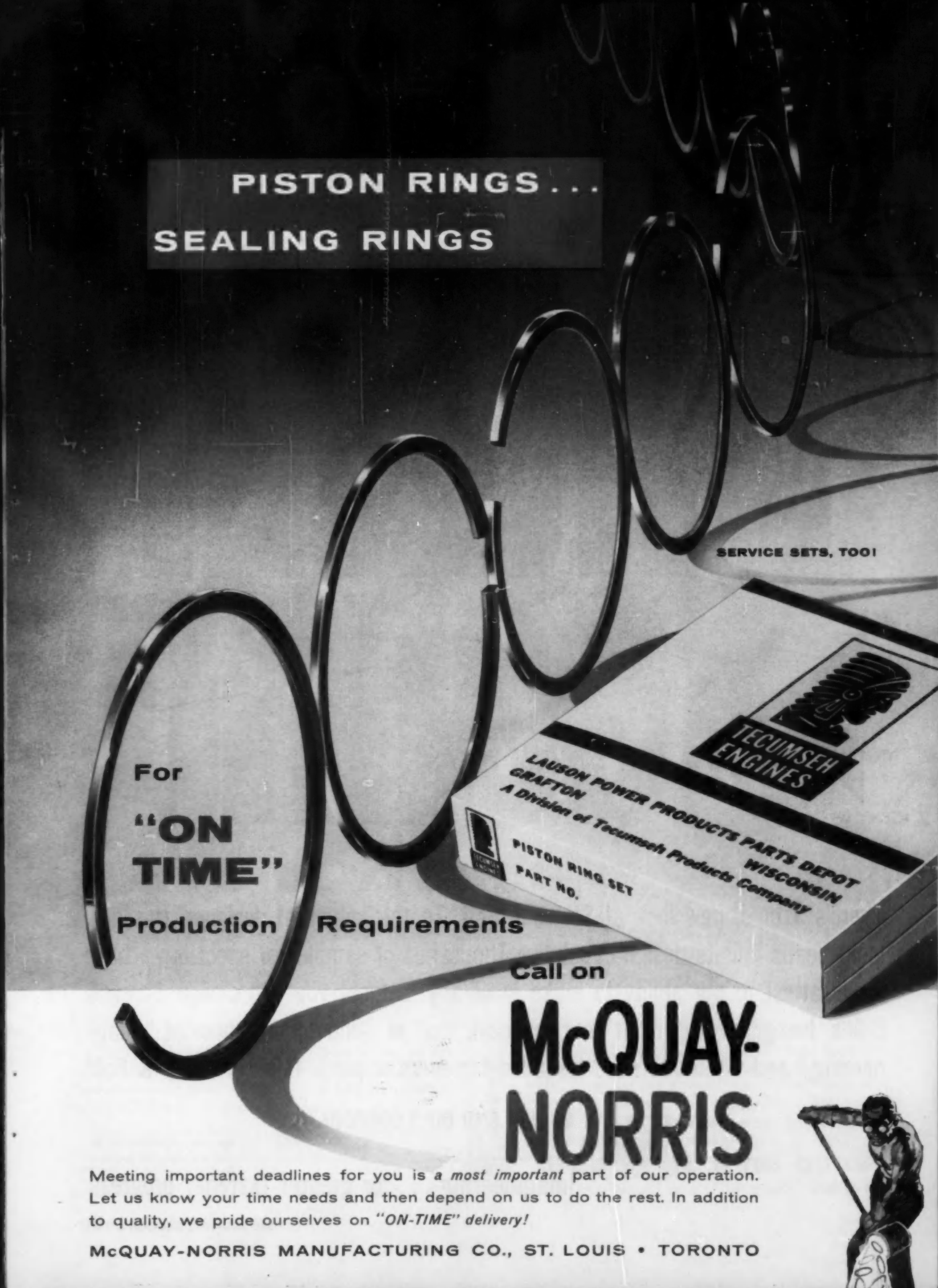
Twin City Section: Edmund Frederick Buryan, Claude B. Myers

Washington Section: Reginald John Monaghan

Western Michigan Section: John Robert Young

Outside Section Territory: John Arthur Crouch, Fred J. Cull, Harold Richard Haines, William Gerald Irvine, Harvey Siegel, Melvin N. Tone, Ronald Clark Tournay, James Wesley Walker

Foreign: Ramachandran Balasubramanian, India; Stephen Frederic Bennett, England; Octavio Reis Filho, So. America; Kenneth Pope Goepfert, Belgium, G. Gopalakrishnan, India; B. K. Gururaja Rao, India; Ulf G. Hammarskiold, Brazil; Gooichi Izuchi, Japan; Talupula Venkobarao Lakshmana Rao, India; Dennis Littlewood, England; Kenneth Harry Platt, England; Krishna Sankarasubramanian, India; Khairat Ullah, Pakistan; Walter Philip Yaneske, England

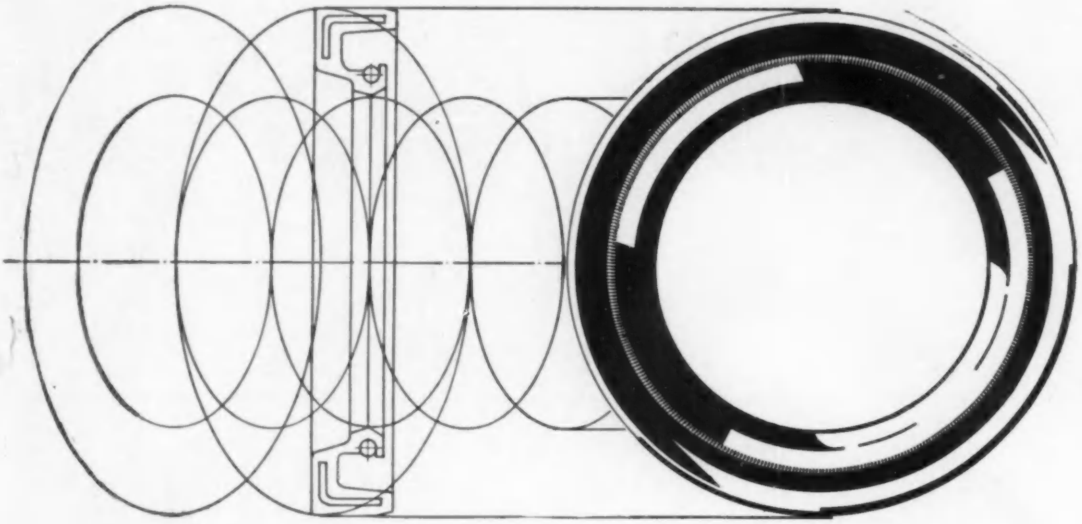

PISTON RINGS...
SEALING RINGS
SERVICE SETS, TOO!
TECUMSEH ENGINES
LAUSON POWER PRODUCTS PARTS DEPOT
GRAFTON WISCONSIN
A Division of Tecumseh Products Company
PISTON RING SET
PART NO.
For "ON TIME" Production Requirements
Call on
McQUAY-NORRIS
Meeting important deadlines for you is *a most important* part of our operation. Let us know your time needs and then depend on us to do the rest. In addition to quality, we pride ourselves on *"ON-TIME" delivery!*
McQUAY-NORRIS MANUFACTURING CO., ST. LOUIS • TORONTO

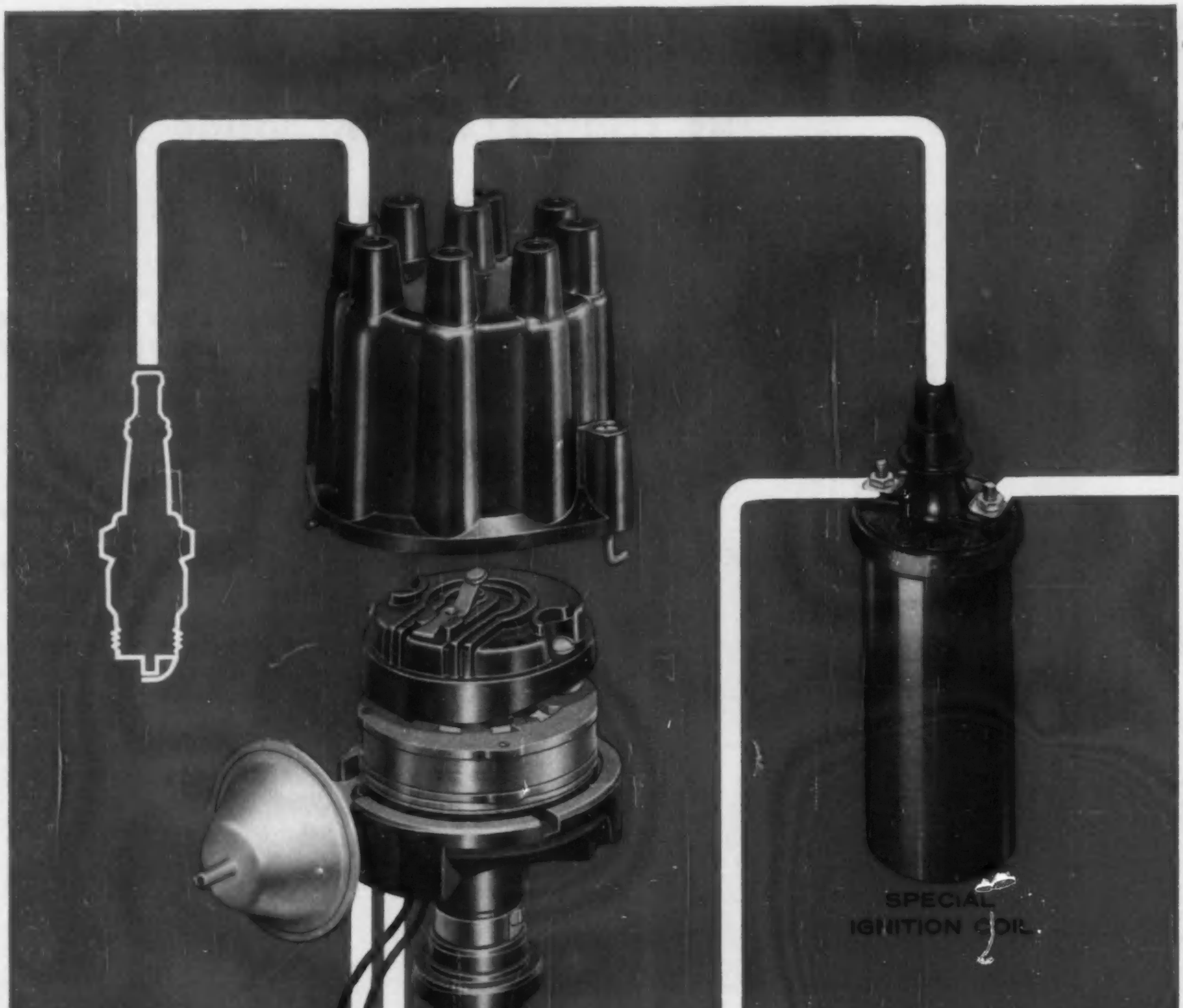
The RIGHT Insert for the Specific Application is Always the Most Economical

For heavy duty service involving extreme wear, corrosion, and oxidation, the highest performance high-alloy seat insert that can be produced is almost certain to be the most economical. On the other hand, for light duty service, a low cost insert of low alloy content may be adequate for the requirements. Eaton produces seat inserts "custom tailored" to meet the demands of each specific application — skillfully blends chromium, nickel, molybdenum, tungsten, cobalt, and iron to provide the right properties to overcome wear, corrosion, and oxidation. The result is inserts which will give optimum life at lowest cost, in the kind of service for which they are designed.

Call our engineers for a consultation on your seat insert problems.

EATON — SAGINAW DIVISION —
MANUFACTURING COMPANY
9771 FRENCH ROAD • DETROIT 13, MICHIGAN




SPECIAL
IGNITION COIL
EXTERNAL RESISTOR
MAGNETIC PULSE DISTRIBUTOR

Greater Mobility and Reliability for Today's Weapon Systems

Typical AiResearch gas turbine generator set

AiResearch gas turbine generator sets are now providing precise electrical power for mobile weapon systems in compact packages less than half the size and weight of previous systems.

These simplified power packages have fewer parts and provide dependable, quick starting and continuous trouble-free operation in any weather extreme.

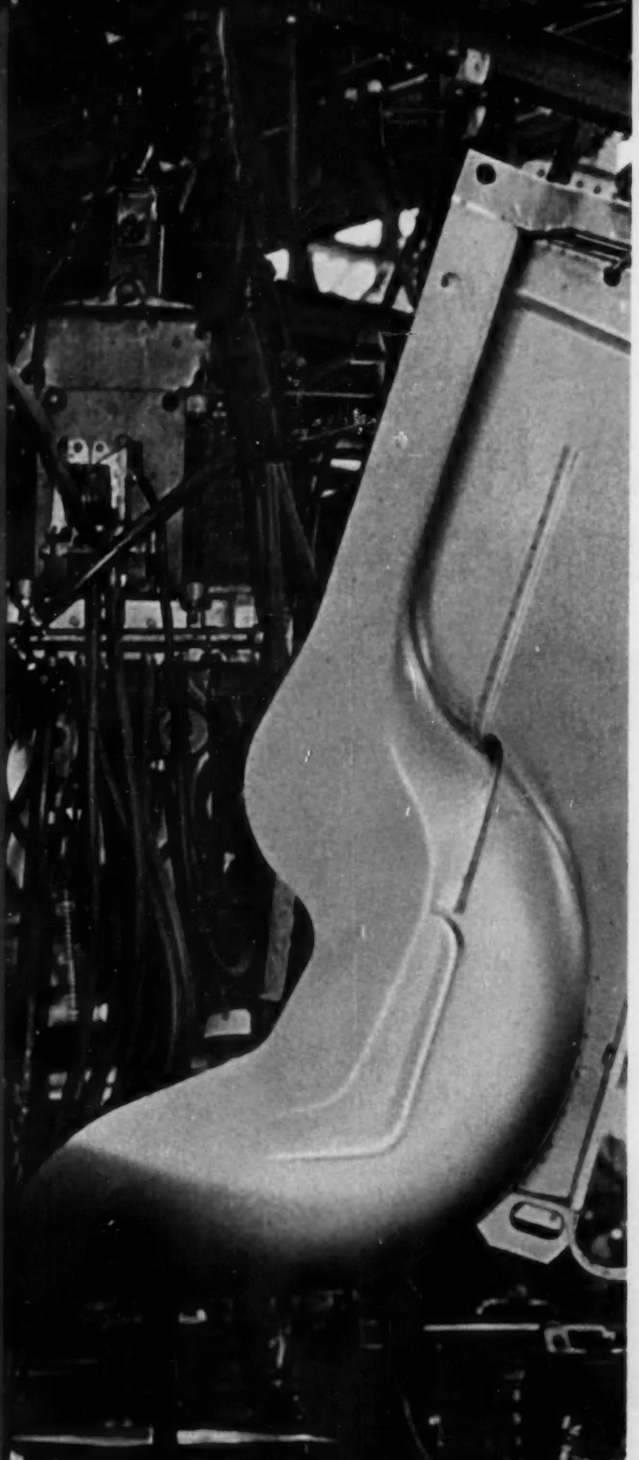
Starting, loading and shutdown are completely automatic, push-button operations. And each package has scientifically-designed sound attenuation to minimize noise.

AiResearch is a leader in the design and production of small gas turbine engines and power conversion equipment. Please direct your inquiries to the AiResearch Phoenix Division.

GARRETT

AIRESEARCH MANUFACTURING DIVISIONS • *Los Angeles 45, California • Phoenix, Arizona*

Systems and Components for:
Aircraft, Missile, Spacecraft, Electronic, Nuclear and Industrial Applications



One in a series of technical reports by Bower

BEARING BRIEFINGS

TESTING PUTS THE HEAT ON—HELPS BEARINGS BEHAVE IN EXTREME ENVIRONMENTS

In industry today, bearing operating conditions are becoming increasingly severe. To conquer difficult environments, heat, corrosion and oxidation, Bower conducts exhaustive research to achieve improved bearing performance. One important area of Bower research, for example, is the development of special alloys to withstand extreme heat. To do this, Bower researchers use special heating apparatus to study hardness, strength and other characteristics of alloys at temperatures in excess of 1000°F.

Bower engineers study how alloys stretch as temperatures rise in excess of 1000°F., to perfect bearings that can take it.

One of the devices Bower utilizes to assure bearing precision at high temperatures is a creep tester. Bower engineers use it to load a test bar to a predetermined stress level, then, with the assistance of a special heating unit, find out precisely how much the bar stretches as temperatures are elevated to a thousand degrees F., and beyond.

With this type of data and the help of other Bower precision research equipment, engineers can determine alloys that best withstand torrid temperatures. They can also effectively mate thermal expansion characteristics of the various alloys used in roller bearing components and in shafts and housings as well. As a result of this mating, Bower creates bearings that maintain precision in the required temperature ranges and ensures bearings that provide long life, heavy load capacity and high-speed operation.

Because of Bower's continuing research in bearing alloys and other critical areas, we suggest you consider Bower to assist you with your bearing needs. Bower provides a full range of types and sizes in tapered and cylindrical roller bearings as well as in journal roller assemblies. Bower Roller Bearing Division, Detroit 14, Michigan.

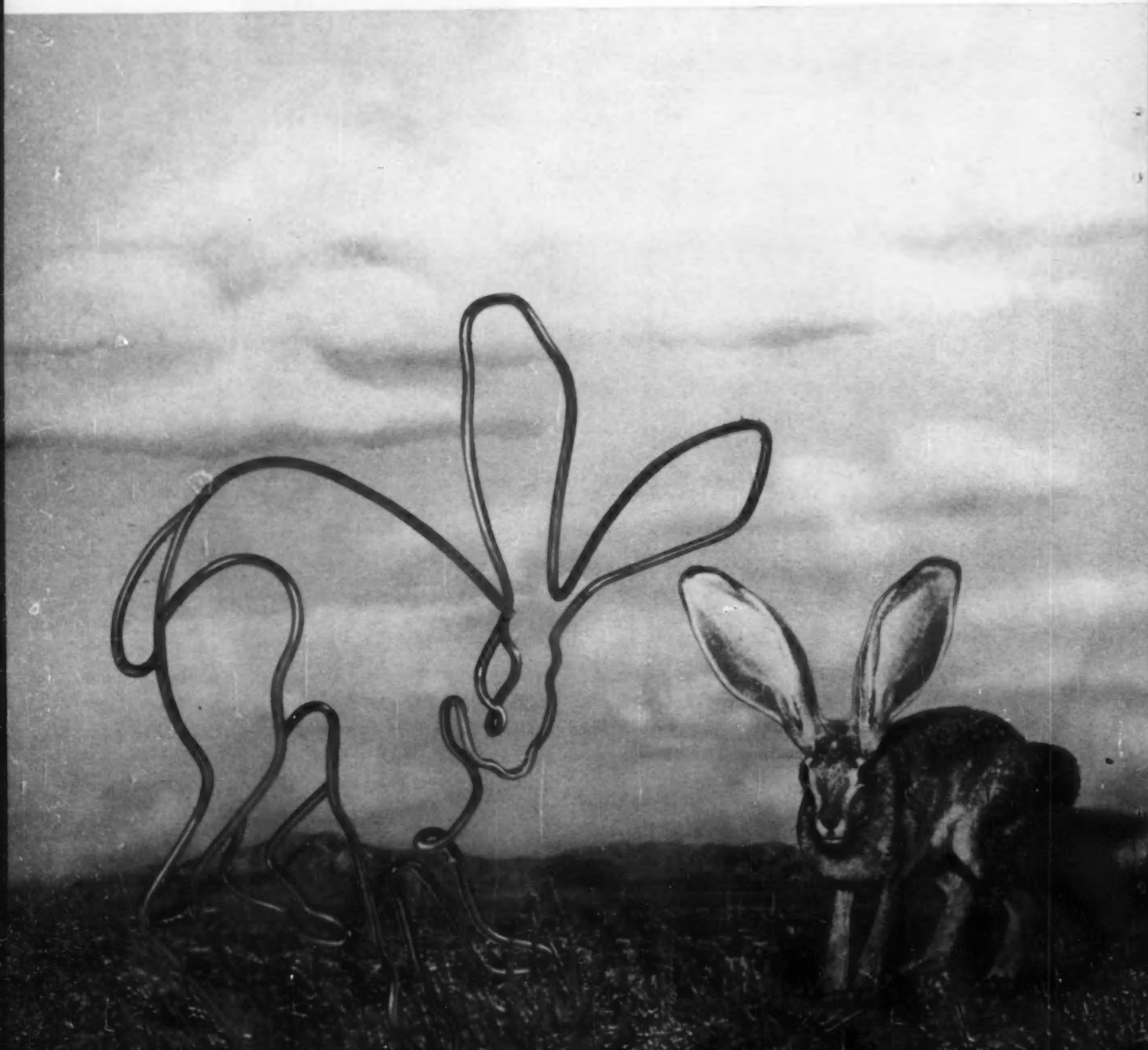
BOWER
ROLLER BEARINGS

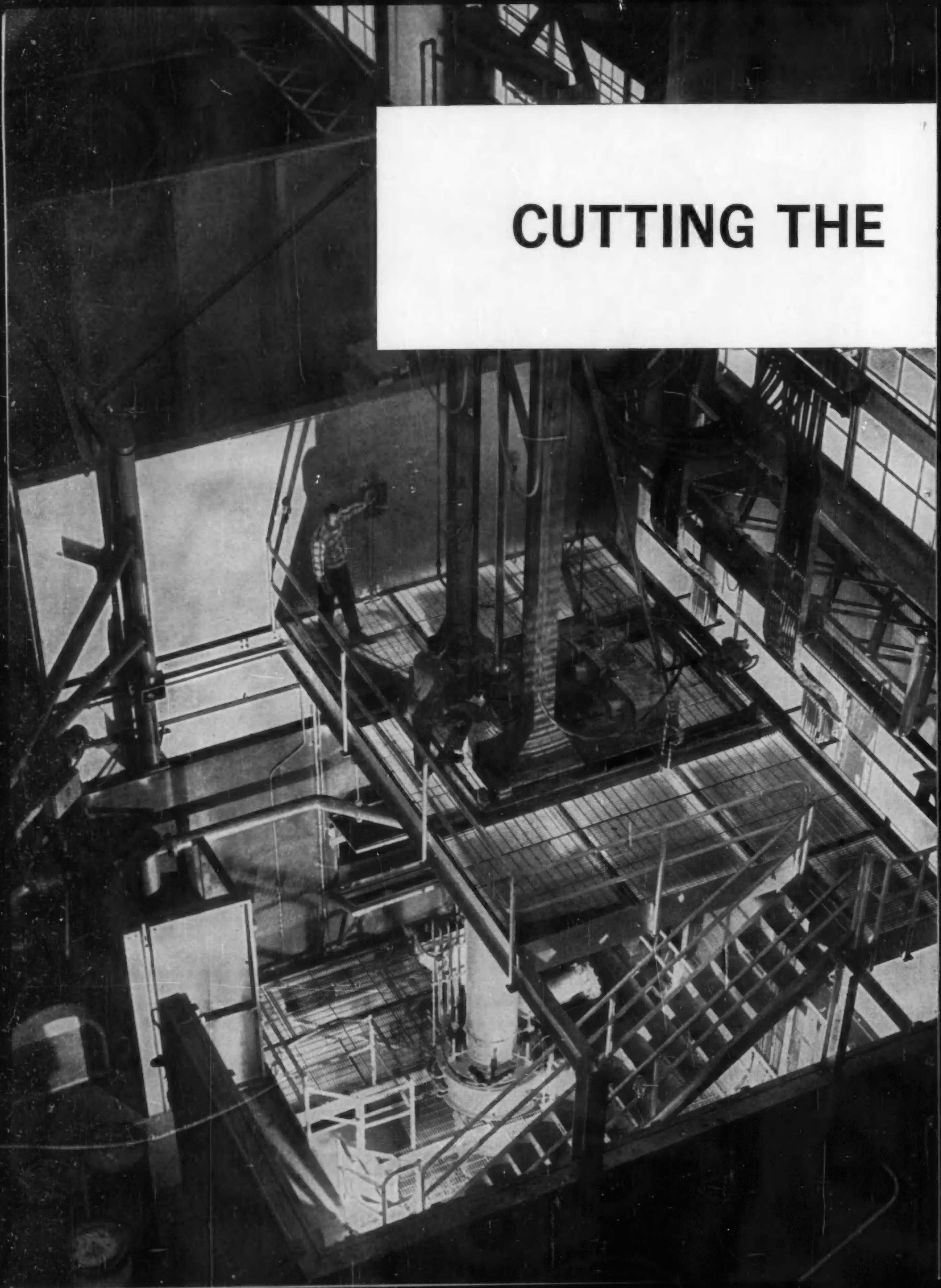
tapered
cylindrical
journal

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.


ONE

Bundy can mass-fabricate practically anything





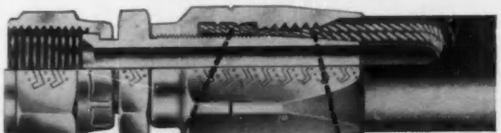
CUTTING THE

INDEX TO ADVERTISERS

WHAT IS YOUR BEST BUY IN REUSABLE HOSE FITTINGS?

Compare
STRATOFLEX
with three other types for the answer!

STRATOFLEX "SCREW-TOGETHER" TYPE

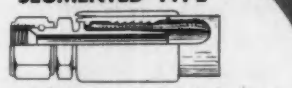


ENCLOSED PROTECTED WIRE

POSITIVE GRIP OF WIRE BRAID

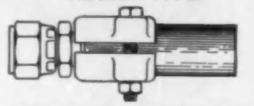
- Minimum envelope dimension
- No special tools required for assembly or disassembly
- Uses standard hose
- Complete reusability
- Pressure rating equal to burst of hose
- Uniform compression
- Long life proven in service

SLEEVE AND SEGMENTED TYPE



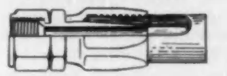
Wire exposed to corrosion • Limited reusability of segments • Large envelope dimension • Special tools and/or equipment required for assembly and disassembly • Non-uniform compression • Limited service history

CLAMP TYPE



Doesn't grip wire • Limited pressure rating • Large envelope dimension • Non-uniform compression • End of hose exposed to corrosion

NON-SKIVE TYPE



High assembly torques • Inconsistent grip of wire • Uses non-standard thin covered hose which has critical tolerances • Special tools required for proper assembly of hose to socket

SF5-1

STRATOFLEX Inc.
P.O. Box 10398 • Fort Worth, Texas
Branch Plants: Hawthorne, Calif., Fort Wayne, Ind.
In Canada: Stratoflex of Canada, Inc.
In Great Britain: Stratoflex (U.K.) Ltd.

SALES OFFICES:
Atlanta, Chicago
Cleveland, Dayton, Denver
Detroit, Fort Wayne
Fort Worth, Hawthorne
Houston, Kansas City
Milwaukee, New York
Orlando, Philadelphia
Pittsburgh, San Diego
San Francisco, Seattle
Toronto, Tulsa

For complete information, write for Stratoflex Catalog 201.